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NOTES ON THE SYMPTOM-SIGNIFICANCE OF DIFFERENT STATES OF THE PUPIL.

BY JONATHAN HUTCHINSON, F.R.C.S.,

Senior Surgeon to the London Hospital, and Surgeon to the Royal London Ophthalmic Hospital.

THE usefulness of the Iris, in its various condition, has long been acknowledged in reference to the investigation of diseases of the nervous system. It has not, however, I think, received as yet that detailed examination which it deserves, and which is necessary, if in the first place we would avoid making wrong inferences; and in the second, if we would avail ourselves of all the help that can be easily got from it. We must not be content to record "pupils contracted," "sluggish," "motionless," "unequal," &c., as the case may be, without pushing on our enquiries as to the pathological cause in each instance of the sluggishness, smallness, or immobility. These several conditions may in turn be due to very various pathological states, and their symptom-significance may be very different in different cases. It is in the hope of helping a little to the clearing-up of this subject that I have written out the following notes. I must own that I feel considerable diffidence in offering them to the readers of BRAIN, since they proceed from the pen of one who is familiar rather with the practical

aspects of ophthalmic medicine than with either modern cerebral pathology or experimental research. On both the latter subjects I must ask indulgence for any ignorance I may display.

In examining the pupil, we concern ourselves chiefly with (1) its shape; (2) its size; (3) its activity; and (4) with any differences in any of these respects which may be observed between the two eyes. In order that errors may be avoided, it is essential that the investigator should employ efficient methods of observation, and also that he should be well aware of all fallacies. As regards the latter, he must understand as definitely as may be how far deviations from what is usual may still be within the range of what is compatible with normal function. I will say a few words on each of the four points.

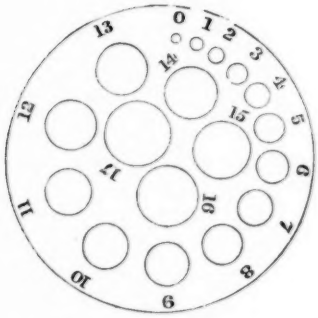
I. *The Shape of the Pupil.*—In the human subject the pupil is, as a rule, round; but slight deviation towards an oval form may not unfrequently be observed under conditions which lead us to regard them as probably personal peculiarities. In glaucoma, and some other diseases of the eyeball, the pupil may become definitely oval. We know, however, as yet, too little about the causes of these deviations from the circular form, as the result of disease, to be able to make much use of them as symptoms. On the other hand, the irregularities which result from adhesions to the lens capsule, and which are so common, are often of the utmost use in helping us to the diagnosis of syphilis on the one hand, or of the arthritic diathesis on the other. I may, perhaps, be here excused for hinting that it is quite possible in cases of old iritis, where the lustre of the iris has been perfectly restored, to overlook the presence of adhesions, and to ascribe the small size and immobility of a pupil, which are due simply to mechanical fixity, to a neurotic cause. This is especially the case when the adhesions are extensive, the pupil round, and the iris of a dark tint. The use of magnifying power is strongly to be urged in all cases in which the pupils differ in size; and if this be not sufficient to clear up all doubt, oblique illumination must be employed, or atropia resorted to.

When synechiæ are found, they are usually attended by

pigment deposits on the capsule also, and it often becomes of great importance to decide as to the character of the iritis which has produced them. Very frequently we have in this question a clue to the diathesis of the patient, and in many cases, especially where syphilitic disease of the nervous system is suspected, the discovery that there has been former iritis may be of the greatest value in support of an imperfect history. It would be out of place here to speak in any detail as to the retrospective value of iritic adhesions; but I may, perhaps, be permitted, on account of the great importance of the matter, to interpolate a few words. If iritic adhesions are found without other changes, and with the history of a single attack of inflammation of the eye in early adult life, they should be allowed very considerable weight as implying a suspicion of syphilis. Under such circumstances, careful enquiry should be made as to other corroborative facts. It is, however, a very dangerous error to assume that almost all iritis is syphilitic, and that therefore adhesions almost always imply that disease. My impression is that arthritic iritis is at least as common as the syphilitic form, and when it occurs it invariably leaves adhesions. The two may, however, usually be distinguished from each other by the history; for the arthritic form always tends to relapse, and often there is the history of an annual or biannual attack during many years. Relapses, on the contrary, are rare in the syphilitic form.

II. *The Size of the Pupil.*—Having often felt the need of some easy means of measuring the pupil, and of expressing its size in note-taking, with more accuracy than the adjectives in common use attain, I have been in the habit of late of employing as a pupilometer the perforated plate used to measure bougies. The accompanying woodcut will explain it, better than any description can, to those who are not already familiar with it. The plate is made of metal, and the holes are numbered 1 to 14. In use I place the plate on the patient's cheek, just below the eye, and turn it until the hole which corresponds in size with the pupil is found. The number of the hole is then noted. The measure is of course only approximative, but having often asked several observers to independently estimate pupils by this means, I have usually found that there was a

very close agreement. It is much simpler and easier of use than the pupilometers hitherto proposed, and its results are, I think, as accurate as can be expected. It may be easily



extemporised by marking out a number of circles on a piece of card.[1] The adult pupil in good daylight averages probably about No. 4, but considerable deviations on each side of this must be expected. The pupils of children and young persons are usually larger than those of adults, and in senile periods still further diminution takes place. Myopic eyes which do not require accommodation usually have larger pupils than others. But independently either of age or sex, or of state of refraction, considerable differences in size must be allowed for as being simply personal peculiarities. Speaking generally, it may, I think, be asserted that there is a relationship between the size of the pupils and the state of the patient's nerve-tone, due allowance being made for age and the other circumstances just mentioned. If the tone be low, the pupils are large. The size of the pupils is almost in inverse ratio with that of the arteries. With relaxed, feeble, and irritable arteries we have usually large pupils; on the other hand, when the arteries are in a state of spasm, as in rigor, the pupils dilate to their

[1] No. 0 measures about one-third of a line; No. 1, two-thirds of a line; No. 2, a line; No. 3, a line and a quarter; No. 4, a line and a half; No. 5, a line and two-thirds; No. 6, nearly two lines; No 7, two lines full; No. 8, two lines and a quarter; No. 9, two lines and two-thirds; No. 10, three lines nearly; No. 11, three lines full; No. 12, three lines and a quarter; No. 13, three lines and one-third; No. 14, three and one-third; No. 15, three and two-thirds; No 16, four lines; No. 17, four and a half.

maximum. These facts are not, as they may at first mention seem, contradictory. In rigor the vaso-motor nerve throws into spasm most of the muscular structures which it supplies, and thus the coats of the arteries and the dilating fibres of the pupil are made to contract. The dilatation of the pupil which goes with a feeble state of circulation is due not to spasm of iris, but to defective tone of the retina and nerve centres, rendering necessary a large supply of light. It may also be due in part to impaired tone in the circular fibres of the iris. No condition of defective tone is more certainly revealed by large pupils than that which results from sexual irregularities in early life.

To come next to more special morbid conditions as influencing the size of the pupil, we may remark that the opinion of our forefathers that the "amaurotic expression" had for one of its chief features a dilated and fixed pupil, is certainly a mistake. It is only in a small minority of the cases of nerve-blindness which count as "amaurosis" that the pupil dilates. A patient may be quite blind with white atrophy of the optic discs, and his pupils may yet be rather smaller than natural. Indeed, in but few amaurosis cases do the pupils remain permanently dilated. In cases of acute optic neuritis with almost entire loss of sight, the pupils almost always dilate widely, and remain for some time at least very large and quite motionless. Indeed, I think it is true that in almost all cases in which blindness is rapidly produced the pupils dilate; whilst, on the other hand, when it comes on gradually, dilatation is seldom seen. In tobacco amaurosis, however far advanced, the pupils, although often very sluggish, are rarely dilated. It is certain that more than mere absence of the incident-excitor influence of sight is needed to produce dilatation of pupils, and it may be admitted that there is much in connection with this subject of which it is difficult to offer a satisfactory explanation.

III. *The Activity of the Pupil.*—In estimating activity, in all cases involving any difficulty it is desirable to take much more pains than is usually done. If the pupil obviously acts well, of course there is no need for further trouble; but if there be doubt, great care should be exercised. The patient should be seated in a full light, and each eye should be examined

separately, the other being carefully covered. The observer will find great advantage in wearing for the moment spectacles of + 10, and approaching his face well within their focus, and thus obtaining, without encumbering his hands with a lens, considerable magnifying power. If the iris be dark, it is especially difficult to be sure as to slight movements. Each eye must be tested separately as to the effect of light, the effect of the accommodative effort, and the influence of exposure of the other eye; and lastly, the two should be tested together in strong convergence.

The activity of the pupils, speaking generally, diminishes with age, and is greatest in the young and vigorous. It is quite possible, however, that it may at times betray a morbid amount of sensitivenesss on the part of the nervous system generally. A pupil which dilates and contracts very frequently and very quickly, is seldom met with in the best-balanced state of nerve-tone, and usually implies debility. Such pupils usually remain when at their smallest larger than natural. We must make at all ages considerable allowance on this point for personal peculiarities, particularly as regards rapidity as distinct from extent of range. Unusually rapid changes probably occur to those whose mental processes, emotions, &c., are also rapid, whilst great width of range, with moderate slowness in its attainment, may perhaps be trusted as an indication of general vigour.

Before testing the activity of the pupil, the state of the retina should always be ascertained. I have already remarked that a dilated pupil is by no means usually met with in "amaurosis," and I may here add that by no means is it invariable, in states of very great diminution of sight from retinal or nerve causes, for the pupil to lose its activity. I have repeatedly seen the pupils act really well to light where the vision was reduced, in both eyes, to little more than ability to count fingers. This part of our subject deserves from the ophthalmic surgeon more detailed investigation. My own observation would lead me to doubt whether in almost any case, however great the degree of blindness, provided the iridomotor nerves remain intact, the pupil becomes motionless. Much in this matter appears to depend upon the suddenness

of the onset. If sight be very rapidly extinguished in an eye previously sound, the activity of the pupil fails greatly; but if the defect come on slowly, it is possible that the fifth nerve may take upon itself the duties of incident excitor. Activity of the pupil then implies for certain a normal state of irido-motor nerves, but it does not imply by any means soundness of the sensory part of the apparatus. We can also investigate the state of the optic nerve and the retina by far surer and more direct methods, and our examination as to activity of the iris will in almost all cases concern rather the state of the third and vaso-motor than that of the optic itself. It remains, however, of much clinical importance, in cases where both are suspected to be diseased, to be able to assign to each its due share.

Sluggishness of pupils may, in a majority of cases, he held to indicate defect in the vaso-motor nerve, and in these cases usually the pupil is either of normal size or rather smaller than natural. In the comparatively rare cases in which sluggishness is found with mydriasis, the third nerve is of course to be suspected, and the state of accommodation must be examined. The presence of ptosis or of defect of some of the third-nerve recti will however, in most of these cases, have already directed attention to the nerve involved. Senile sluggishness is almost always attended by a degree of myosis, and is indicative of failure of the vaso-motor. It is possible that its degree may be used as an indication of the state of the vaso-motor throughout the body.

When a pupil which is itself sluggish on direct exposure responds immediately when the other eye is exposed, we may infer—1st, that the irido-motor apparatus is sound; 2nd, that the percipient structures in the second eye are sound; and, 3rd, that there is some defect in the percipient structures in the first eye. On the other hand, there are cases in which an eye which can see perfectly and enjoys good use of accommodation, yet has a pupil which does not act in the least on alternate shading and exposure of its fellow. In these cases the demonstration is clear that there is some interference with the integrity of the motor nerves. The absence of cycloplegia leads again to the suggestion of disease in the vaso-motor. If

in addition to this absence of iridal susceptibility to influence from the other eye, we have also failure of accommodation, then the triad of symptoms is complete, and we must suspect the lenticular ganglion itself.

IV. *As to Differences between the two Pupils.*—I shall have to say so much on these in other parts of my paper that I will not here do more than just hint that it is necessary to guard against erroneous inferences by remembering that precise symmetry of pupils as to size is exceptional rather than the rule.

It is desirable as a preliminary to explain and define certain terms, some of which are already in general use, whilst others, which are more or less novel, seem much wanted.

By the old term MYDRIASIS we denote a state of great dilatation of the pupil. For practical purposes we recognise three forms: the *artificial*, which is produced by the use of drugs; the *paralytic*, which follows usually defect in the third nerve; and the *spasmodic*, which is due to spasm of the radiating fibres of the iris.

The term MYOSIS is the opposite of Mydriasis, and is applied to any condition of unusual smallness of the pupil. We have the same three forms that have just been mentioned in the case of Mydriasis.

IRIDOPLEGIA is a term applicable wherever both circular and radiating fibres of the iris are paralysed, and the pupil fails wholly to respond to the stimulus of light. The power of acting under the excitement of drugs is not usually lost; indeed, this power as a rule fails only when the muscular substance of the iris is itself disorganised. In Iridoplegia we have united the conditions which, when present singly, constitute respectively paralytic myosis and paralytic mydriasis.

CYCLOPLEGIA is a condition so closely connected with the iris that, although it is not, strictly speaking, a condition of the pupil, it will be convenient here to mention it. It is due to paralytic failure of the ciliary muscle, and is attended by absolute loss of the function of accommodation.

OPHTHALMOPLEGIA INTERNA is a term which I have recently

proposed to denote the condition in which both circular and radiating fibres of the iris and also the ciliary muscle are all simultaneously paralysed. Here we have entire cessation of muscular action within the eye. It is necessary to use the adjective *interna* because there is an important group of cases of simultaneous paralysis of all the external ocular muscles for which the name *ophthalmoplegia externa* is wanted.

Although I have mentioned spasm of the various muscular structures as a condition which may produce converse states to those of paralysis, yet, as a matter of fact, we know but little of it in connection with disease. In the laboratory, states of spasm may easily be produced, and the pupil may be made to contract or dilate at pleasure; and hence we may assume that it is probable that spasm sometimes complicates the conditions we witness in disease. But it is, probably, only a temporary state, and the proof of its presence is usually difficult to find. We are familiar in practice with troublesome conditions, in which the ciliary muscle is easily thrown into spasm, but as regards spasmodic mydriasis and myosis, we know but very little. When the dilatation or contraction of the pupil is extreme in degree, we may suspect that spasmodic contraction of the muscle concerned exists, for we know that paralysis of either sphincter or dilator rarely produces extremes of either condition. But in all these examples of extreme conditions, it is probable that paralysis is present, and is the chief agent in the production of the symptoms. There is, perhaps, no reason to believe that states of permanent contraction or dilatation of the pupil ever depend upon spasm alone. We have, in the state of the pupil during rigor, and during the epileptic paroxysm, in some cases, good examples of spasmodic mydriasis. Dr. Hughlings-Jackson has recorded examples of dilatation of the pupil during epilepsy, with smallness of the retinal arteries. I have myself repeatedly examined the pupil during severe rigors, and have found it dilated to an extreme degree, coincidently with almost entire absence of the pulse, a cold skin, and pale, death-like countenance. Here we clearly have a state of spasm of the arteries, and with it we should, of course, expect spasm of the radiating fibres of the iris, since they also are supplied by the vaso-motor nerve. I am not familiar with any example of the converse condition

of spasmodic myosis, but in some of the cases of pinhole pupil in brain disease, it may plausibly be suspected that spasm of the circular fibres is present, especially since we know that complete paralysis of the vaso-motor nerve, whilst it entirely prevents dilatation, by no means produces extreme contraction.[1]

The muscular nerve-supply to the iris is, as is well known, from the vaso-motor and the third. The short root of the ciliary ganglion comes from the branch of the third supplying the inferior oblique, whilst from the carotid plexus proceed vaso-motor filaments, which, after passing through the same ganglion, are distributed to the interior of the eye, and mainly to the radiating fibres of the iris. It is probable, however, that the radiating fibres of the iris receive a part of their nerve supply independently of the ciliary ganglion. Hensen and Völcker found that, after section of the roots of the ganglion in the dog, stimulation of the sympathetic in the neck still caused dilatation of the pupil. In Foster's *Text-book of Physiology*, where these experiments are referred to, it is almost implied that the long ciliary nerves, and not those from the ganglion, are those which carry the vaso-motor filaments to the iris. It is probable, however, that both sets share in this duty, and very possible that considerable differences exist in different individuals. The ciliary muscle is mainly supplied by the third. If, therefore, disease existed in the short root before it entered the ganglion, or in the branch from which this root is given off, we should expect paralysis of the circular fibres of the iris and of the ciliary muscle. As a matter of fact, in cases of total paralysis of the third nerve, including of course this root, these conditions are present. The pupil is always considerably larger than natural, and shows no power of contraction on

[1] Spasmodic Mydriasis is induced with unvarying certainty by electric irritation of the corpora quadrigemina, more especially of the nates. First, the pupil of the opposite side dilates, but very soon that of the same side also. The eyes at the same time are widely opened, and the eyebrows elevated. The eyeballs are directed upwards to the opposite side. If the left tubercle is irritated, both eyes are directed to the right." Knoll[a] has shown (1869) that this dilatation of the pupils from irritation[b] of the corpora quadrigemina does not follow, if the trunk of the cervical sympathetic has been divided.

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[a] Eckhard's *Beiträge*, 1869.

[b] See Ferrier, page 78.

exposure to light, but it is by no means always extremely dilated. The loss of accommodation is usually almost complete. Disease in the short root itself, and limited to it, is of course rare, but I have diagnosed it in one or two instances by the symptoms of paralytic mydriasis and cycloplegia, without anything else. It is quite possible also that these two symptoms, which are usually combined, may be separated, and that the mydriasis may exist without the cycloplegia, or the cycloplegia without the mydriasis. Such cases are, however, rare, and they are probably to be interpreted by the suggestion of central disease; for it is not likely that disease in any part of the third nerve, or in its branch, the short root of the ciliary ganglion, could destroy entirely one set of fibres, and not implicate another travelling in the same bundle. The state of eye so often met with after diphtheria, affords us the best instance I know of cycloplegia without mydriasis. It is known to be attended by paralysis of the velum palati, and sometimes by pharyngeal or even by limb paralysis also. Its precise pathology is, I think, not yet satisfactorily made out, but the inference from the eye symptom would be that it must be central.

Much has been written on the state of the eye caused by paralysis, from injury or otherwise, of the cervical sympathetic. So far as the pupil is concerned, observers differ only in their estimates of the degree of contraction. In physiological works, and in some clinical ones, contraction of the pupil, or paralytic myosis, is spoken of as the common condition. My own observation would rather lead to the belief that not contraction, but simply inability to dilate, is the usual condition. The pupil remains of the size usual when the eyes are in full light, and if the surgeon inspect his patient under such conditions he may easily overlook the condition. This once happened to myself. If, however, the eyes be shaded, then at once the pupil of the sound eye dilates, and, leaving its fellow motionless, a marked difference in size becomes at once conspicuous. I have examined the state of the pupil in about six examples of paralysis of the cervical trunk of the vaso-motor, and in none was its size ever less than about No. 4. In Plate XXXIV. of my *Illustrations of Clinical Surgery*, I have figured

the conditions in strong light and in shade, showing also the peculiar diminution of the palpebral fissure, which is such a remarkable feature of this lesion. In the same work (Vol. I., p. 212) I have given the particulars of several cases, and have referred to others, in which it was distinctly stated that the pupil was contracted.[1]

Thus we have seen that if disorganisation of any part of the third nerve, involving the fibres of the short root of the ciliary ganglion, occur before these fibres reach the ganglion, paralytic mydriasis will result, with more or less of dilatation of pupil, total inability to contract when exposed to light, and further loss of the function of accommodation. We have seen also that if the trunk of the cervical sympathetic be disorganised, or its ocular branches at any point behind the ciliary ganglion, paralytic myosis or at any rate inability to dilate on the part of the pupil must result. These nerves travel quite apart until they reach the ganglion in question, and so far as anatomists have yet shown, they do not possess any nucleus in common. In the ciliary ganglion, however, they meet, and become closely associated, and the fibres which leave that body to pass forwards into the eye, to the iris and ciliary muscle, contain filaments of both. What would be the result of extirpation of this ganglion, or of its complete destruction by disease? Manifestly we should expect an entire paralysis of the internal muscles of the eye,—the dilator of the pupil, the constrictor of the pupil, and the ciliary muscle. The pupil would remain absolutely motionless, and the patient would be unable to read without glasses. Such cases occur, and it is to them that I propose to apply the term *ophthalmoplegia interna*. They are usually in connection with syphilis, and often both eyes suffer together. As to size of the pupil, it will vary somewhat with the age of the patient, but will, I believe, usually range from No. 4 to 6. Nothing is noticed as regards peculiarity, unless the activity of the pupil be carefully tested; but the patient will probably come under care complaining of

[1] See an important paper by Dr. William Ogle, in the *Medico-Chirurgical Transactions* for 1860; also some 'Clinical Notes on Paralysis of the Ocular Branches of the Cervical Sympathetic Nerve,' by myself, in the *Ophthalmic Hospital Reports*, Vol. V., 1866.

his imperfect vision for near objects. If there be no other symptoms excepting the ophthalmoplegia interna, I think the diagnosis of disease in the ganglion is justified, for it is scarcely possible that it can be anywhere else. We must, however, keep our minds open to a certain degree of doubt, on the score that it is just possible that at some point in the centres these two nerve twigs (part of third and part of vaso-motor) may come into relation. It is the absence of all other nerve symptoms which gives us confidence as to location; for, of course, if other parts of the third were implicated, another diagnosis as to anatomical site would become necessary.

Here, then, we have a theory of the possible occurrence of pupils sluggish to the extent of absolute immobility without central disease, and in consequence solely of disorganisation of a little peripheral ganglion. Nothing in respect to it has as yet been proved by post-mortem examination, but the suggestion is, I think, of considerable interest for the student of cerebral pathology, since pupils in this condition might easily excite suspicion of more deeply-placed disease.

Although the diagnosis of ophthalmoplegia interna may be made with most confidence when it occurs without complication, yet we must remember that it is very possibly present and in connection with the same lesion in many complicated cases. Whenever the pupil is motionless and the accommodation lost, the lenticular ganglion should be suspected, even although there may be clear evidence of disease in other and perhaps in distant parts.

(*To be concluded.*)

MOTOR-FEELINGS AND THE MUSCULAR SENSE.

BY GEORGE HENRY LEWES.

THE fact that we have feelings accompanying the movements of our limbs and contractions of muscles, and that such feelings are specifically distinct, is admitted on all hands; the assignment of these feelings to the motor apparatus, and their subsumption under the rubric of a Muscular Sense co-ordinate with the other Senses, is one of the vexed questions.

Muscular tissue forms the larger proportion of the tissues constituting the organism. It enters into the composition of every organ, and is so abundantly supplied with nerves that Krause affirms every single muscle fibre to have its nerve fibril.[1] This, however, would have little significance on the current hypothesis which excludes the muscle-nerves from participation in sentient phenomena, confining them to motor-phenomena. To me it has great significance, as I shall here attempt to show.

Note, first, that Motility and Sensibility are the distinguishing properties of the animal organism. Sensation always passes into motion of some kind, and all movements are stimulated and regulated by sensory excitations. We separate in abstraction these two elements of an inseparable unity; and having for analytical purposes made this ideal distinction we easily come to imagine it real. We thus separate the sensory and motor nerves, though in reality they are integrated by ganglionic substance into one nervous arc. In other words, sensory-impulse and motor-impulse are the polar aspects of one vital process. The sentient mechanism is essentially a neuro-muscular mechanism, each neural portion of it having an ingoing nerve, a central mass, and an outgoing nerve, with

[1] KRAUSE, *Allgemeine und mikros. Anatomie*, 1876.

a centripetal and centrifugal "current" of Neurility. These polar aspects represent the antithesis of passive and active; which antithesis is further extended to represent Sensation, the subjective fact, a state of the sentient organism, and Movement, the objective fact, a change in the space-relations of the body.

The psychologist must admit the presence of a motor element in every feeling; but in consequence of the tendency to classify according to marked differences, he separates the motor feelings as a class apart, precisely as he separates those of the Systemic class from those of Special Sense. In each case he throws the whole stress on what is peculiar to it, leaving out of account all that it has in common with others; thus in optical and auditory feelings only the sensibilities to light and sound are specified, without regard to the muscular sensibilities which form integrals of optical and auditory feelings. The psychologist will likewise accept a class of motor feelings such as cannot be included under any one of the Five Senses—feelings of Effort, Resistance, Movement, Fatigue, which have characters not less distinct than those of Colour, Temperature, Sound, or Taste. Whether these are to be included under the general term Muscular Sense is a question of classification; whether they are in any respect assignable to the muscles and their innervation, or are simply the result of muscular contractions in exciting cutaneous and articular sensibilities, is a question of fact. On the latter point opinions are divided.[1]

In meditating the arguments *pro* and *con* it has seemed to me that the phenomena have not always been recognised as very complex; at any rate one factor, or set of factors, has been urged in explanation of facts which involve many. Under the general term Muscular Sense we find included feelings derived 1° from motor impulses; 2° from motor intuitions; 3° from muscular contractions; 4° from the effect of such contractions on the skin, &c.; 5° from muscular co-ordinations;—or in

[1] The literature of this subject is enormous. In every physiological text-book there is a section on it, and in every scientific journal may be found essays on it. The reader may profitably consult BASTIAN, in the *British Medical Journal* for May, 1869; and BERNHARDT, *Archiv für Psychiatrie*, 1872.

popular language, feelings *prompting* and *accompanying* ideal movements, not executed; and those prompting and accompanying real movements.

Everyone's consciousness discriminates between the passive affection of a sense organ, or a surface, and the active state of an organ. If for convenience we call the first *sensation*, and the second *motor feeling*, we may define sensations as complexes of peripheral stimulation and central reaction. Although not rigorously exact (since what are called "subjected sensations" arise from central stimulation), this is sufficiently exact for general purposes. The motor feelings, on the contrary, appear to be complexes of central stimulation and peripheral reaction; though this also is qualified by the fact that sometimes the peripheral reaction is absent, or non-apparent. Here a change in the centre is a motor impulse discharged through motor nerves, and exciting contractile tremors or full contractions in the muscles. This is the initial stage of the motor feeling (though the final stage of the sensory impulse), and it is followed by the peripheral reaction: namely, the contractions with their accompanying *effects* on the skin and articular surfaces. This is the second stage, and is succeeded by another change in the centre, effected by the peripheral reaction playing back upon the centre. Into these three stages, therefore, we may analytically resolve the motor feeling. The second stage is obviously compounded of purely muscular and purely cutaneous sensibilities. If this be so, we must regard it as a great mistake to assign muscular sensations to either of the two factors in exclusion of the other; and also a mistake to assign them to both, in exclusion of the central process of innervation.

A movement is effected by muscular contractions; these muscles are innervated from a centre; they have envelopes and attachments, and, when they contract, these envelopes and attachments are pressed, stretched, and folded; the limbs cannot move without—by their ball and socket arrangement—pressing on the articular surfaces. However indispensable nerves, muscles, and skin may be as conditions in the production of muscular sensation, yet it is not the nerve, the muscle, the skin, each by itself, nor all combined, which is the seat

of feeling: for *that* we must invoke the Sensorium. Does this appear a truism? Then why is it so disregarded, as it is by those who imagine that they disprove the existence of a Muscular Sense when they prove the motor nerve and muscle to be insensible?

The outgoing nerves which move the muscles are appropriately named motor; the ingoing nerves which transmit surface stimulations are as appropriately named sensory. But here, again, having named things differently, our terms are made to carry conclusions: the outgoing nerve is denied all participation in the production of a sentient change because it is not called *sensory*. On similar grounds we might deny that the ingoing nerve has any participation in the motor change because it is not called *motor*. Nay more, the sensory nerve is only one condition in the production of sensation, it is not itself the seat of sensation, and, apart from the centre in a living organism, it also is insensible. The principle I have so often insisted on—that identity of structure implies identity of property—must here also be applied; the ingoing and outgoing nerves are identical in structure and property: both have the same Neurility, both transmit their excitations, both are blended with the central nerve substance, and both form integral elements of central activity. The nerves have different functions, or (to speak more accurately) different functional relations, because of their different anatomical distribution; but because of their common Neurility, and their common integration in the centre, they must both be conditions of sensibility. *Neither can be in action without thereby inducing a change in the central equilibrium.* The discharge on an outgoing nerve must be accompanied by a corresponding change in the state of the discharging centre. The feeling which is conspicuous after any unusual effort must be present in kind, though less conspicuous, after every effort. If we cannot cease a violent pull without being conscious of a feeling at the time of the effort, and of another feeling when the effort ceases, it is presumable that fainter feelings accompany the feebler efforts.

But let us come to the experimental evidence. That the motor nerves are only agents in the production of movement,

and never of feeling, is said to be proved, because while they are known to convey central discharges to the muscles, they are incapable of conveying peripheral stimulation to the centre. This may be so, yet if so would prove nothing of the kind. But *is* it so? The proof offered is that when a motor nerve is stimulated, muscles move, but no sensation is excited. This is very questionable; indeed, one cannot but point to a strange oversight on the part of those who adduce this statement. They admit that muscular contractions do *somehow* cause sensations. No one disputes it; yet experiments are adduced in which muscular contractions are said not to have their invariable concomitants. What is true is, that when the motor nerve is stimulated, muscles are moved, and no indication is given by the animal of any sensation accompanying the movement. And this is intelligible. If the sensations exist at all, they must be muscular sensations, and will not therefore manifest themselves in signs of *other* sensations. When the optic nerve is stimulated, the sensation is optical, not auditory; it is that of flash, not of a pain. So when a muscle nerve is stimulated the sensation must be muscular. It is perfectly true that the muscle may be pinched, lacerated, burned, and no sign of sensation be manifested by the animal. These are not the adequate and normal modes of excitation of the motor nerve. It does not respond to them any more than the skin nerve responds to light, or the optic nerve to sound.

But, as I said, if the asserted facts were admitted, they would not carry the conclusion. We do not prove the motor nerve to be excluded from the *mechanism* of sensation by proving that it is not competent of *itself* to produce sensation. This premised, let us pass to the other argument—the *cheval de bataille* of those who uphold the essential distinction between sensory and motor nerves. A nerve is divided, thus separating from the centre the muscles to which the nerve is distributed. The portion of this divided nerve which is attached to the centre may be stimulated in any way, no sensation will be manifested; whereas, when the portion which is attached to the muscles is stimulated, these muscles move. Here, then, sensation and motion seem divorced: the more because in the

reversal of the experiment, by the division of a sensory nerve, stimulation of that portion which is attached to the centre does produce a sensation.

This negative evidence is far from decisive. If the stimulation of the motor nerve produces no appreciable change in Consciousness, this may be simply because the stimulus is not adequate and normal; for we know that inadequate stimuli leave the sensory nerves unappreciably affected. No one will conclude that the sensory nerves of the alimentary canal are insensible, because disease may eat away the membranes yet the patient be wholly unconscious of the injury. The normal and adequate stimulation of a motor nerve is the *motor impulse* discharged from its centre, and, probably, the *recurrent wave* excited by the contraction.

The outgoing impulse is admitted by all writers. The recurrent impulse is more hypothetical, and I believe I was the first writer who suggested it, and on these grounds: if we admit the Neurility of ingoing and outgoing nerves to be the same, we have no more reason to suppose that each nerve can only be excited at one end, and transmit its excitation in only one direction, than that a train of gunpowder can only be ignited at one end, and propagate its ignition in only one direction. Dubois Reymond long ago proved that each nerve conducts electricity in both directions; and the experiments of John Hunter and Bert on animal grafting prove that Neurility may be so conducted. Grafting the tail of a rat under the skin of the rat's back, the tip of the tail being inserted under the skin, its base rising into the air, is a complete inverting of the normal position; nevertheless, pinching this grafted tail produced the sensation of pain; and so accurately was this sensation localised that the rat turned round and bit the pincers. Other experiments show the same transmission in a contrary direction. Indeed, we have only to remember that the axis cylinder of the nerve is semi-liquid, to see at once that it will as readily conduct a wave in one direction as in another. Therefore I assume that when a nerve acts upon a muscle, the contraction *reacts* upon the nerve; and this gains fuller probability from the fact that between axis cylinder and contractile substance there is very considerable homo-

geneity. By this reaction the motor nerve affects the centre; so that not only do the sensory nerves which are stimulated by the contractions send their ingoing influences to the centre, but, accompanying these, the motor nerves also send their recurrent influence.

Waiving this hypothetical recurrent wave in the motor nerve, we have the less-disputable elements of—1°, a sentient change in the outgoing discharge; and 2°, the change arising from the ingoing stimulation of the sensory fibres distributed to the skin and articular surfaces; and 3°, perhaps also of sensory fibres distributed to the envelopes of the muscles, and to the interstices of their bundles.[1] A muscular sensation is a complex of these sentient changes. It is composed of changes in central innervation, changes in the active state of the muscles, and changes in their organic states. It ranges through the gamut from muscle-tone to muscle-tetanus; from contractile tremors to contractions. Even when in repose the muscles are faintly quivering; this is called their tone, and may be likened to the state of the retina when in perfect darkness, which even then has what Helmholtz picturesquely calls its *luminous dust*—a kaleidoscope of colours, now deepening now brightening,—till watching it we begin to think the ancients had some justification in calling the eye the source of light. The varying tone of muscles enters as a factor in the general state of Sentience, though rarely discriminated in Consciousness. It is one main element in languor and vigour. It is a measure of the resistance opposed by muscles to the motor impulse. This resistance in turn is a stimulus, so that greater effort succeeds. When the tension in the muscles is high, nutrition having supplied a store of disposable energy, a slight impulse excites it, and the energetic contraction which ensues, reacting on the centre, gives the feeling of power and freshness so eminently

[1] The existence of sensory fibres distributed to the envelopes of muscles and penetrating between the bundles is asserted by SACHS, *Archiv für Anatomie*, 1874, p. 195; and ARNDT, *Archiv für mikros. Anat.* ix. p. 481. We must remember, however, that all methods hitherto employed for determining such questions are open to many illusions; the only decisive evidence—that of actually tracing a fibre from centre to periphery—is impossible; and the experimental evidence always involves an assumption of the main point.

pleasurable. The fresh, vigorous animal delights in exercise. The vigorous mind feels a similar delight in overcoming resistance in the combination of ideas.

Are these feelings due solely to the foldings and stretchings of the skin and to pressures on articular surfaces, when muscles are contracted? Are they due to changes in the Sensorium produced by the outgoing impulse? Each of these opinions finds eminent advocates. Let us examine them. "When a blind man," says Bell, "or a man blindfolded, stands upright, neither leaning upon nor touching aught, by what means does he maintain his erect position? The symmetry of his body is not the cause. A statue of the finest proportion must be soldered to its pedestal, or the wind will cast it down. How is it, then, that a man sustains the perpendicular posture, or inclines in the due degree towards the wind that blows upon him? It is obvious that he has a sense by which he knows the inclination of his body; and that he has a ready aptitude to adjust the parts of it, so as to correct any deviation from the perpendicular. What sense is this? He touches nothing, sees nothing; it can only be by the adjustment of the muscles that the limbs are stiffened, the body firmly balanced and kept erect. In truth, we stand by so fine an exercise of this power, and the muscles from habit are directed with so much precision, and with an effort so slight, that we do not know how we stand. But if we attempt to walk on a narrow ledge, or rest in a situation where we are in danger of falling, or balance on one foot, we become subject to apprehension; and the actions of the muscles are then, as it were, magnified, and demonstrative of the degree in which they are excited."[1] If we watch an infant learning to walk, or attend to our own sensations when learning some new muscular movement, we shall become aware of the necessity of a very fine sensibility for all these adjustments. It is only by means of guiding sensations that we can perform such actions.

There still remains the question whether the sensations derived from muscular contraction can in any degree be referred to the muscle-nerves. Schiff maintains that all the phenomena attributed to the muscular sense are due to the

[1] BELL, *On the Hand*, p. 238; 5th edition.

foldings and stretchings of the skin when the muscles contract. Spiess and Schröder van der Kolk hold the same view. And there is much to be said for it, though, as I before intimated, all the evidence adduced in its support only proves that one among the several factors is the effect of contraction of the skin. In a paper of mine, read at the British Association in 1859, were recorded decisive experiments (reproduced in the *Physiology of Common Life*, vol. ii. pp. 284 *sq.*) showing that muscular adjustments could not be wholly due to cutaneous sensibility. These are confirmed by clinical observations of partial and even complete cutaneous anæsthesia with little or no loss of muscular feeling and co-ordination. The patients are conscious of motor impulses, and are able to co-ordinate their movements: under what conditions, and with what amount of completeness will presently be noted. A frog deprived of its skin exhibited the same co-ordinations of a complex order as a frog intact. Not only so, but a frog without its brain and without its skin, exhibited similar co-ordinating power. Nothing here remained except the mesencephalic and spinal centres, and the ingoing and outgoing nerves; but the ingoing nerves were no longer capable of being stimulated from the surface, the skin having been removed; and accordingly neither pinching, pricking, burning, nor any other irritation of the surface caused the faintest sign of sensation; if, therefore, the ingoing nerves played any part at all here, it must have been through the sensory fibres distributed to the muscles and the articular surfaces. But these could only be affected when the muscles had already been *moved;* consequently, the motor impulse carried through the outgoing nerves must have been antecedent to any passive sensation caused by ingoing nerves. This conclusion enables us to explain how even after destruction of the sensory channel, by division of the posterior roots, movement and co-ordination were still possible. I found the locomotive co-ordination still effected, not perfectly, it is true, after the posterior roots of one limb were divided; and Brown-Séquard, after division of the roots of all the limbs! Such evidence is not to be gainsaid by the fact that injuries to the posterior roots, or even anæsthesia of the skin, very

seriously disturb co-ordinations in the higher animals. We are here concerned only with showing that movements *may be* effected, co-ordinated (and felt?) in the absence of the passive sensibilities which arise in the cutaneous and deep-seated nerves. Duchenne cites cases of absolute insensibility to pricking, burning, and even electrical stimulation, in patients who felt any movements their limbs might be forced to execute—felt the movements they executed themselves—felt the resistance that opposed them; in fact "chez eux la contractilité volontaire n'éprouve aucun trouble dans son action physiologique." (*De l'électrisation localisée*, 1861, p. 425.)

Let us now, having disproved the hypothesis which assigns the phenomena to the so-called passive sensibilities due to ingoing stimulation from the surface, pass to the hypothesis which assigns them to the active sensibility of the outgoing discharge. This hypothesis takes two forms, a physiological and a metaphysical. Dr. Clifford Allbutt briefly expresses the first in these terms: by muscular sense he means "the consciousness of the varying states of Neurility in the motor nerves, and of tension in the central cells connected with them." (*British Med. Journal*, Feb. 20th, 1869.) Professor Bain expresses it thus: "The sensibility accompanying muscular movement coincides with the *outgoing* stream of nervous energy, and does not, as in the case of pure sensation, result from any influence passing inwards by incarrying or sensitive nerves." The sensitive nerves are, he thinks, "the means by which the *organic* states of the muscle affect the mind. It does not follow that the *characteristic feeling of exerted force* should arise by an inward transmission through sensitive filaments; on the contrary, we are bound to presume that this is the concomitant of the outgoing current by which the muscles are stimulated to act." (*Senses and the Intellect*, p. 77.) To the same effect Ludwig and Wundt, the latter establishing a distinction between innervation-feelings and muscle-feelings. (*Physiologische Psychologie*, p. 316.)

The metaphysical form of the hypothesis is that we are endowed with a "native power" of estimating the force necessary for each movement; just as we are by some philosophers believed to be born with an intuition of Space, and a "sense of

distance." In this view, Force is the direct revelation of Consciousness, which, when projected into the external world, appears as Cause. Independent of and antecedent to all experience, we know the degree of Force, or Effort, which a movement demands: this is a birthright of the Soul.

A combination of the metaphysical and physiological view may be found in Johannes Müller, who was too good a physiologist to adopt the purely metaphysical view, and too much of a metaphysician to adopt the physiological view thoroughly. "It is not certain," he says, "that the idea of the force employed in a muscular contraction depends solely on a sensation. We have a very exact notion of the quantity of nerve-force starting from the brain which is necessary to produce a certain movement." This is true, or false, according to the point of view: it is true if the notion is a *motor intuition framed out of registered experiences*—just as we have an exact idea of a circle before we draw it; an exact idea of the pain which will follow a prick, before the pin touches the skin; an exact idea of the distance of an object before we stretch our hands to seize it. But these illustrations show the error of the view which, placing the cart before the horse, supposes the notion to have been in existence *before* movements which it ideally reproduces had originally produced it. And the error becomes conspicuous in the light of clinical evidence that when there is anæsthesia the patient is utterly incapable of regulating the force. Not only does he cease to hold an object on ceasing to look at his hand, but he is so unable to regulate his muscular energy that he crushes a brittle object when he grasps it, as an infant crushes a butterfly; and if he grasps your hand, it is spasmodically—he cannot lessen the pressure at your request. The estimate of force is independent of the muscular sensation only as the idea of a circle is independent of the power of drawing it. I may have a mental vision of a human face, but my attempt to draw on paper what I thus see will be successful only in proportion to the education of my muscles. The registered experiences of former efforts have furnished me with motor intuitions; but the carrying of these into effect depends upon the motor feelings being normal—the numbness of cold, or the pain of rheumatism, will disturb the mechanism.

It seems clear that the two hypotheses of passive and active stimulations, derived through the ingoing and outgoing nerves, having both an array of evidence showing that a feeling of movement involves sensibilities of the two kinds, leave us no alternative but to include both, and not assign the feeling to either separately. The evidence proves that muscular adjustments and motor-feelings may exist when there is anæsthesia of the passive sensibilities: therefore these latter cannot be the sole sources of the co-ordination and muscular feeling. But the evidence also shows that the passive sensibilities normally enter into the complex feeling, and any diminution of them is a disturbance of the co-ordination, and a variation in the quality of the feeling; the disturbance of co-ordination may be nullified to some extent by the co-operation of some other passive sensibility, notably that of sight, but nothing will nullify the variation in quality. Let us glance at the evidence.

A patient whose cutaneous sensibility is lost can supply its place. He walks steadily so long as he can "lean upon his eyes as upon crutches;" he can reach an object if he looks towards it; he can hold one so long as his attention is directed towards it. Close his eyes, and he staggers, moves his arms wildly; call off his attention, and the object falls from his hand. Some patients cannot even stand when their eyes are closed. Have they then lost their muscular sensibility? This has been rashly concluded. It is disproved by the co-ordination: this certainly is not *effected*, it is only *aided*, by sight. The loss of the accustomed sensations derived from the skin has disturbed the accustomed *quality* of the complex feeling, and, although the sense of Effort remains, the sense of Effect is absent. The patient does not feel the usual consequences of a movement, and therefore does not know whether it has taken place or not, unless his sight informs him; and, since the Sensorium requires that it should be informed at each step whether the movement has been effected before it innervates the successor, a bewilderment ensues; which may be faintly appreciated by any one studying his feelings when moving in unfamiliar places in the dark, or even when closing his eyes and trying to reach an object on the table. The movements

so accurately and unhesitatingly co-ordinated with the aid of sight, now become tentative and inappropriate. A similar case is that of the deaf man becoming dumb: no longer hearing perfectly the sounds he utters, no longer rightly informed of the effect, he first loses his power of rightly adjusting the efforts—speaking now in tones scarcely audible, and now in shouts—and, as the deafness increases, he finally loses the power of speech. It should be added that only such movements as we are accustomed to direct by sight are capable of being thus directed when there is cutaneous anæsthesia. We, who were not born blind, learn to direct our feet in dancing, and our hands in manipulations of complex kinds, by looking at them. Movements of the eyes, tongue, glottis, &c., are not thus aided. They are learned through the muscular feelings—as the pianoforte-playing of the blind is learned. But any considerable disturbance of the usual elements of a process must cause a disturbance of co-ordination. Heydt has shown, by experiment, how great a disturbance accompanies anæsthesia of the soles of the feet (*Der Tastsinn der Fuss-sohle*, 1862), but oven this may be compensated by attentively watching the steps.

After giving due weight to the evidence which shows the dependence of feelings of movement on the normal influence of cutaneous sensibility—evidence we have already intimated as merely disclosing one factor,—let us now consider the other side. There are cases on record of marked defect of co-ordination where *no* appreciable defect in cutaneous sensibility existed. The cases, indeed, are rare;[1] I had the good fortune to study one under Prof. Friedreich at Heidelberg. The patient was a girl, about twenty, healthy in all her organic functions, and with well-nourished, powerful muscles. The sensibilities of her skin were perfectly normal, responding to every stimulus in the normal way. Her localisation of impressions was normal. She could bend or stretch arms, fingers, legs and toes at will; and the power over her muscles was such that I could not with my utmost force bend or

[1] VULPIAN says: "On a cité quelques cas très-rares dans lesquels la sensibilité était restée intacte bien que les phénomènes d'ataxie locomotive fussent très-prononcées. Je n'ai jamais vu de cas de ce genre."—*Archives de Physiologie*, 1868, p. 118. In TROUSSEAU'S *Lectures on Clinical Medicine*, translated by BAZIRE, p. 209, two good examples are given.

straighten a limb, if she resisted me. But her co-ordination was so imperfect that she could not walk unless leaning on some one, and even then threw out her legs in a spasmodic and disorderly manner. Nor were her upper limbs more under control. If she attempted to reach an object, or to clutch one presented to her, the movements were singularly incoherent, and never succeeded until after many corrections of the effort. It took her several minutes to button her dress, though finally she always succeeded. In short, there was a great disturbance in the ordinary regulation of movements of the limbs—(those of respiration, facial expression, speech, &c., were normal),—although her skin was unaffected. I remarked to Prof. Friedreich that I had seen a frog with the sensory nerves of one limb wholly destroyed, and another with no skin at all, yet the movements in both cases were far more co-ordinated than those of this girl.

This curious example raises many questions which I cannot touch on here. It is an example of abnormal irradiation, and consequent failure of co-ordination, rather than of any absence of purely muscular feeling. The girl had muscular movements and muscular sensations, but failed to combine the movements with normal precision; the volition was normal, but there was a defect somewhere in its execution.

The experiments of Wundt (*Sinneswahrnehmungen*, p. 410) seem to prove that the muscular feelings cannot be wholly due to foldings and stretchings of the skin, or pressure of surrounding parts, in the case of the movements of the eye. The convergence and divergence of the axes, and the accommodations of the lenses, are accompanied by feelings which enable us to estimate the relative positions and distances of objects. This cannot be due to pressures: because, in the first place, the muscular sensibility is by Weber shown to be more delicate than the tactile, being indeed in the proportion of 39 : 40—a delicacy which rivals that of the higher senses, whereas the tactile is only 29 : 40; and because, in the second place, the power of estimating distance through accommodation lies within the limits of contraction; whereas, if the object, instead of approaching the eye, recedes from it, we lose all power of estimating distance when the muscles relax

instead of contracting: our estimate is then a judgment formed from the varying size of the image.

Finally, consider the marked differences in the quality of the feeling under the following circumstances: I move my fingers by a voluntary effort; you then move my fingers in the same directions, I neither opposing nor resisting the movement. In both cases the *effect* is the same—the muscular contractions, the stretchings and foldings of the skin, are the same; but in the first case there is present what is absent from the second, namely, the element of *effort*. Now suppose that I am suffering from cutaneous anæsthesia, I shall then feel the effort, but not the effect; so that unless I am looking at my fingers, I shall be unable to say whether I have moved them or not, and whether another has moved them or not. Herein we see disease analysing the two elements of a muscular feeling, active and passive, central impulse and peripheral reaction.

The Muscular Sense, to be exhaustively treated, would demand a careful survey of the facts of co-ordination and of motor intuition, which would require another essay; so that for my present purpose I must be content with the foregoing remarks. What this paper professes to show is, that although the motor sensibility is a constituent of all Feeling—since Feeling is a complex of passive reception and active discharge —there is a justification for the establishment of a special and distinct class of sensations produced by muscular movements, and for these the term Muscular Sense is appropriate. Such sensations are complexes of neuromuscular active and passive sensibilities; and although their seat is neither in muscles nor in nerves, but in the Sensorium acting on and affected by nerves and muscles, we have the same ground for including the motor nerves among the *essential conditions* of production of muscular sensations, as for including the optic and auditory nerves among the essential conditions of production of sight and sound sensations.

ON THE RÔLE OF THE DURA MATER AND ITS NERVES IN CEREBRAL TRAUMATISM.[1]

BY H. DURET,

Aide de l'Anatomie de la Faculté de Médecine, Paris.
&c., &c.

THE part which irritation of the meninges, and particularly of the dura mater, may play in cerebral traumatism, forms an important subject of investigation. In lesions of the cranium and cerebral membranes, and of the subjacent cerebral cortex, the physiological action of these sensory structures may be excited. Their varied and, so to speak, protean manifestations tend at each moment to complicate the whole symptomatology, by superposing themselves in the phenomena due to lesions of the nerve centres proper.

This complication should be avoided at all hazard, and we shall endeavour to show how this can be done.

After a short anatomical sketch of the nerves of the meninges, we shall demonstrate successively that irritation of these sensory conductors may produce hyperæsthesia, pain, and reflex motor and vaso-motor disturbances, and we shall inquire whether irritation actually occurs in connection with cortical lesions, and what are its symptoms.

Sketch of the Anatomy of the Meningeal Nerves.

(A.) Nerves of the Dura mater.

Froment, Arnold, Cruveilhier, and Bonamy have given the

[1] This forms Chap. III. of M. Duret's thesis, *Sur les Traumatismes Cérébraux*, of which we have been enabled to give an analysis from unpublished advanced sheets kindly supplied us by the author. At M. Duret's desire we have extracted the above chapter in its entirety, with the exception of the details of the experiments referred to.—Editors, 'BRAIN.'

best description of the nerves of the dura mater. These nerves all spring from the fifth pair, and are divided into anterior, middle, and posterior.

The *anterior* arise from the ethmoidal branch of the nasal, and are distributed around the ethmoidal fossa and the roof of the orbit. The *middle* spring directly from the Gasserian ganglion, and proceed outwards: "They plunge immediately into the substance of the dura mater, says Cruveilhier, *nearer the internal than the external surface*, and ramify in all directions over the temporo-sphenoidal region, and up to the parietal region of the membrane; several of the branches become lost in their course, two or three can be traced to the neighbourhood of the superior longitudinal sinus.[1]

The *posterior* take their origin from the ophthalmic branch of Willis, not far from the Gasserian ganglion, cross the trochlear nerve, to which they are so closely applied, as to give rise to the idea that they spring from this nerve; and arrive at the tentorium cerebelli, where they divide into internal and external branches. The internal, two or three in number, course inwards, so as at once to gain the base of the falx cerebri, into which they pass and ascend towards the vertex. The external direct their course towards the lateral sinus, and bend so as to reach the posterior part of the falx cerebri, in which they lose themselves.

Do these nervous filaments, *which are situated nearer the inner than the outer aspect of the dura mater*, end in special terminal organs, which increase the delicacy of their sensibility? We are inclined to believe this, on account of the marked physiological troubles which ensue on their irritation.

(B.) Nerves of the Arachnoid and Pia mater:

Luschka and Bochdalek have described nerve fibres in the arachnoid. According to Kölliker, these filaments belong to the vessels of the pia mater. It is certain that a large number of the nerve fibres coming from the sympathetic accompany the carotid and vertebral arteries in the cranium.[2]

Purkinje and Kölliker describe nerve plexuses at the base of

[1] Cruveilhier, *Traité d'Anatomie descriptive*, 4th ed. p. 313, tome iii.

[2] Claude Bernard and Vulpian have demonstrated that section of the sympathetic in the neck causes dilatation of the vessels in the brain.

the cranium surrounding the arteries of the circle of Willis. Their fibrils accompany the vessels which proceed from this, and are distributed with them over the whole of the pia mater. "I have lately succeeded in following them," says Kölliker, "into the substance of the brain, as far as the vessels of ninety millimetres and less."

All these nerve fibres which accompany the arteries so far are the vaso-motor nerves of these vessels. They are the agents of the reflex vascular disturbances, of which we shall have occasion to speak so often.

II.—*Irritation of the Nerves of the Dura Mater can cause Pain.*

Van Helmont, and the physiologists of the school of Stahl, regarded the dura mater as the seat of sensation. Hence the ancient experimenters carefully investigated the sensibility of this membrane.

Haller, Zinn, Bordenave, Housset, &c., maintained that in animals this membrane may be cut or lacerated without causing signs of pain.

Lecat, on the other hand, attributed to it a sensibility more exquisite than that of the skin. Longet says that on slightly scraping the dura mater with a scalpel, towards the base of the skull and the tentorium cerebelli, the animal gives unequivocal signs of pain. According to Flourens,[1] the sensibility becomes exalted by inflammation.

Cruveilhier admitted that the dura mater was insensible to section, but that it appeared very sensible to laceration: "Having had occasion frequently to apply the trephine to the skull of dogs, I have remarked that the animal remained quiet all the time that the action of the saw was limited to the bone. But, as soon as the teeth of the instrument touched the dura mater, the animal manifested signs of acute pain by brusque movements and shrill cries."[2]

MM. Brown-Séquard and Vulpian do not doubt this property of the dura mater. For my own part, I have, on

[1] Longet, *Traité de Physiologie*, t. iii. p. 297.
[2] Cruveilhier, *Traité d'Anatomie*, t. iii. p. 343.

many occasions, confirmed the exquisite sensibility of this membrane; it is particularly shown when one seizes it between pincers, or scrapes the serous surface. A certain degree of force is necessary to affect nerve fibres situated in the substance of the fibrous tissue, but at the internal surface, slight contact is sufficient to cause pain. Certain animals utter painful cries, and do not cease for some time after the dura is pinched. In several, even where sensibility seemed abolished generally, in consequence of cerebral traumatism, I have caused *plaintes* and reflex movements by irritation of this membrane.

III.—*Irritation of the Nerves of the Dura Mater causes reflex Movements of the Muscles of Animal Life (Face, Limbs, Eyes, Pupils, &c.), and of the Muscles of Organic Life (Heart, Vessels, &c.).*

The physiological criticisms, which the theory of cerebral localisation was subjected to in its infancy, have placed this property of the dura mater in a prominent light.

Certain opponents have adduced these facts to prove that the localised movements, which are determined by the application of the electrodes on the pretended motor centres of the cortex, were in reality due to irritation of these sensory conductors. We shall not enter on the discussion; the theory of cerebral localisation has won the day.

It is now more generally admitted that the movements caused by irritation of the dura mater are reflex, and not so localised or so definite as those caused by irritation of the cortex.[1]

[1] The movements produced by irritation of the dura mater are not more localised than those which follow pinching of the sciatic. According to the intensity of the mechanical stimulus, in this case, the spasms are limited to the muscles of the leg on the same side, or extend to the muscles of the opposite one, then to the trunk or upper extremities, and lastly become general. The march is similar in the case of irritation of the dura. The movements which result have never the exact localised character of the contractions caused by irritation of the cortex. The movement of cortical origin is not diffuse; it occupies a group of muscles well defined, and resembles a voluntary movement, combined, or *intentionnel*, as M. Vulpian expresses it. The same difference exists between the two orders of movements, when they seem to be limited, each to a small group of muscles, as between the closure of the eyelids on the approach of a foreign body,

But let us see what are the characters of these reflex movements. Marshall Hall[1] (*Med. Chir. Trans.*, vol. iv., 1841, p. 122) was, we believe, the first to announce that irritation of the dura mater caused convulsive reflex action. In 1872 Dalton, in his experiments before the New York Committee for inquiry into the results indicated by the physiological *localisateurs*, observed convulsions in the limbs in consequence of irritation of the dura mater in animals. But, according to him, these convulsions occurred on the same side as the irritation; whereas, when the motor centres were irritated, the convulsions occurred on the opposite side.

Carville and myself, in our experiments on the cortex, have also observed the same phenomena: and in order to avoid complication of these movements with those resulting from excitation of the motor centres, we resected the dura mater, or insulated it with a plate of glass. Nevertheless, we believe that the distinction drawn by Dalton is too precise: for frequently we observed that electrical or mechanical irritation of the dura mater produced reflex spasms and energetic movements of the opposite side, and often of the two sides, face and limbs.

Recently M. Bochefontaine has made a detailed investigation of the influence of irritation of the nerves of the dura mater on reflex movements. "The cranial dura mater is endowed with sensibility in certain parts of its extent, since irritation of these points determines, as is well known, cries of pain, and also general movements more or less energetic. But mechanical excitation of the sensitive points of the dura mater may produce, in certain conditions, movements limited to one or several parts of the body. These facts have been observed in dogs which have been submitted to experimentation for the investigation of the excitability of the cortex. The animals have been, some etherised, others chloralised by injection into the veins, and others slightly curarised; part of the cranium having been removed to expose the dura mater.

Under these conditions, if one gently scratches the dura

and the closure of the eyelids by an act of volition. The one is brusque and unequal, the other is precise and measured.

[1] *Med. Chir. Trans.*, vol. vi. 1841, p. 122.

mater with the points of the dissecting forceps, at a point situated over the middle central region, the eyelids of the same side are immediately shut. Sometimes the same excitation causes elevation of the upper lip and ear, with deviation of the nose on the side. A stronger irritation of the same sort causes simultaneous movement of the limbs on the same side; of the tail, which turns to the side of lesion, and of the face as indicated. Lastly, stimulation still more powerful, and two or three times repeated, determines movements of both sides of the face, in the neck, and in all four limbs. The movements of the limbs on the same side are more energetic than those of the opposite side." [1]

When, by incision in certain directions, the nerves of the dura mater are severed from their connections with the nerve centres in the medulla, they lose their property of producing reflex movements under the influence of mechanical stimulation (Bochefontaine).

M. Bochefontaine and myself have observed this peculiarity, that irritation of the *anterior parts* of the dura mater causes reflex movements chiefly of the eyelids and facial muscles; irritation of the *middle* parts produces more particularly movements of the ear and of the subcutaneous cranial muscles; while irritation of the *posterior* parts causes movements especially of the subhyoidean muscles and those of the back of the neck.

We have also observed very violent contractions, almost tetanic in character, in the muscles of the nape of the neck in consequence of irritation of the dura mater at its entrance into the spinal canal. The excitation of the nerves of this membrane, if it is slight, causes also *contraction* of the pupil; if it is intense or long continued, it causes *paralysis* of the iris. Lastly, we have to add, that during the same excitation we have frequently noticed nystagmus and spasms of the oculomotor muscles.

No surprise need be expressed at the extraordinary and

[1] Bochefontaine, 'Sur quelques particularités des mouvements réflexes déterminés par l'excitation mécanique de la dure-mère crânienne'; note com. par M. Vulpian à l'Acad. des Sciences, 7 août 1876 et com. à la Soc. philomathique en *Journ. de l'Institut*, 23 août 1876.

extensive range of the reflex movements provoked by irritation of the dura mater, for two reasons, the one physiological, the other anatomical; (1) the course of the sensory impressions from the dura to the sensory centres is very short. With certain exceptions (the palm of the hand, and sole of the foot, which possess special terminal sensory organs) the less the distance between the point of irritation and the sensory centre, the greater the reaction. The rapidity and power of nerve force vary in arithmetical progression, inversely as the distance and directly as the intensity of the stimulus. Greater effects are produced by irritation of the spinal roots than by irritation of the peripherical branches or of the trunk of the sciatic. (2) Because, according to the researches of M. Pierret, Professor of the Lyons School, the centres of the trigeminus occupy the whole length of the medulla, and are in intimate relation with the *centripetal* fibres which ascend from the spinal cord.[1]

The nerves of the dura mater being centripetal have the properties of this set of conductors. Claude Bernard, MM. Couty and Franck have established the remarkable influence of the irritation of sensory nerves on the movements of the heart and respiration. According to the intensity of the stimulation these movements are retarded or suspended.

Cl. Bernard, Brown-Séquard, Schiff, Vulpian, &c., have shown that irritation of sensory nerves determines, locally or at a distance, vaso-motor disturbances (contraction and dilatation) often of great intensity. To this group of phenomena is given the name of *sensory vaso-motor reflexes*. "If," says M. Vulpian, in his able Treatise on the Vaso-motor Apparatus, "the central end of the cut sciatic is irritated, not only the vessels of the other limb contract, but also the most of the vessels of the body. This result is constant, and may be shown by a hamo-dynamometer in connection with one of the carotids. This apparatus indicates a notable rise in the blood pressure each time the central end of the sciatic is irritated. This elevation of pressure can only be accounted for by con-

[1] In locomotor ataxy it is not unusual to trace the lesion of the posterior columns as far as the trigeminal nuclei, of which the cells may be altered. Pierret, *Thèse de Doctorat*, Paris, 1876; et com. *l'Acad. des Sciences*, 1876.

traction of the small vessels, and by the consequent obstruction of the capillary circulation, for the effect is the same whether the vagi are cut or left intact." He adds further, "The same phenomena are also manifested under the influence of irritation of the trigeminus, and almost all sensory nerves, as well as of the posterior roots of the spinal nerves." The nerves of the dura mater, branches of the trigeminal, have analogous properties, but their influence appears to be specially exerted on the cerebral vessels. Mechanical and chemical irritation of the nerves of the dura mater cause intense vascular disturbances in the globe of the eye and corresponding cerebral hemisphere, and, often, in both eyes and both hemispheres.

I have not made any experiment with the electric stimulus. But here is an experiment which clearly shows the powerful influence of the nerves of the dura mater on the vessels of the eyes and brain. It refers to an injection of iodine between the cranium and the dura mater, by a small orifice in the cranium, chemical irritation having a more lasting effect than electrical. In this experiment are to be noted—Excessive acceleration of the respiration, contractures and dilatations of the pupils, rigidity of the extremities, occurring very soon after the injection; coma and intense vascularity of the brain: effects due to irritation of the nerves of the dura mater, for the tincture of iodine had not penetrated the membrane.

Exp. LXI.—*Injection of a small quantity of tincture of iodine between the cranium and dura mater.—Excessive acceleration of the respiration.—Immediate contraction of the limbs.—Action on the pupil.—Ocular and cerebral vaso-motor disturbances.—Momentary coma.—Death.*

[Experimental details omitted.]

(C.) To sum up, irritation of the nerves of the dura mater may cause: (1) Reflex spasms and contractures in the muscles of animal life (limbs, trunk, head, neck, eyeballs); (2) modifications of the respiratory and cardiac rhythm, contractions and dilatations of the pupils; (3) vaso-motor disturbances in the eyeballs, and cerebral hemispheres (hence, somnolence and coma), especially on the same side.

The knowledge of these facts has an important surgical application; for a spiculum of bone, irritating the dura mater by a sharp angle, a subosseous sanguineous clot, may cause such phenomena. In this relation the following experiment is of interest.

Exp. LXII.—*Depression of the skull on the right and then on the left.—At the moment of depression, cries of pain.—Acceleration (momentary) of the respiration; contraction of the pupils.—Trepidation and muscular spasms in the limbs.—Transitory somnolence.—Recovery.—Death by pithing.*

[Details omitted.]

Remarks.

(1.) Anatomical.

These depressions, though considerable, these flat splinters, though the animal lived five days, and though they projected about one centimetre into the interior of the cranium, had not produced any lesion of the dura mater or of the subjacent hemisphere.

(2.) Physiological and symptomatological.

(1.) After the first experiment (splinter depressed by graduated blows) I observed no indication of commotion, *i.e.* no arrest of respiration, no slowing of the pulse, no tetanic phenomena, no loss of consciousness, &c., but simply *trepidations* and *spasms* of the muscles of the shoulders, first on the *same side* then on the opposite, and in the ears, *during about three quarters of an hour.* I also noticed that the animal uttered cries of pain and distress long after the shock, as if it had the sensations caused by the presence of a *foreign body.* All these facts harmonise with the researches of M. Bochefontaine and my own on the dura mater, from which it appeared to be a membrane *very sensitive,* and of which pinching or irritation provoked on the same and also on the opposite side, spasms of the muscles of the shoulders, ears, nape of the neck, face, &c. We are therefore entitled to attribute these phenomena to the irritating action of the splinter on the dura mater, rather than to affection of the subjacent cortex, since this was found quite intact after death, and inasmuch as the phenomena were

principally on the same side as the lesion. The transitory contractions and dilatations of the pupils belong also to the same category of facts.

(2.) In the second part of the experiment (depression of the left side of the skull by violent blows) all the phenomena observed are to be attributed to shock produced by violent concussion of the cranium.

They are the phenomena of cerebral commotion.

(3.) The condition of the digits and paws [intermittent rigid extension] is a phenomenon to be ascribed in all probability to the irritation of the dura mater—a reflex intermittent contraction.

(4.) The pulse and temperature were normal during the whole of the first part of the experiment, a further proof that there was no cerebral commotion.

In the second part there was a notable fall in the temperature after the shock. At 5h. 4m.: P. 46; T. R. (rectal) 39°; and a little later Resp. 13. At 5h. 20m.: P. 80; R. 17; T. R. 37·8°. The following morning (Oct. 6): P. 98; R. 19; T. R. 40°. On Oct. 7: P. 92; R. 20; T. R. 38·4°.

Cases will be referred to in the second part of this work of observations in man, where disturbances have been observed attributable to irritation of the nerves of the dura mater. In particular, M. Tillaux has communicated to me the case of a young girl, who, in consequence of irritation of the outer surface of the dura mater, exhibited contractures of her ocular muscles, and signs of cerebral congestion, such as mental hebetude, tendency to sleep, &c. She recovered completely after the cause of irritation had been removed by spontaneous opening of an abscess in the middle ear. I have already related in the Société de Biologie the remarkable case of a patient, who, in consequence of a depressed fracture of the anterior part of the parietal bone on the left side (over a non-motor region) was paralysed, by compression, on the right side. He remained profoundly comatose for three days. Now during those three days my friend and colleague, Dr. Blain (de Bernay), frequently noticed violent spasms, and even contracture of the face and limbs of the *left side*. On the fourth day Dr. Blain removed the fragments, and the patient recovered

rapidly from his paralysis, his contractures, and his coma, which had subsisted till then. In my opinion, the paralysis on the right side—the side opposite of the lesion—was the effect of compression of the left hemisphere; but the spasm and contracture of the *left* side (the side of lesion) was the result of irritation of the dura mater by the depressed splinter. As these muscular spasms, this contracture, existed from the beginning, and could not be attributed to irritation of the cortex, since the lesion was not over a motor region, and occurred on the same side as the lesion, an indication was furnished for surgical interference. I shall relate other observations of the same kind in the second part of this work.

IV. *Relations between lesions of the dura mater and of the cortex as regards their symptomatology.*

(A.) The analysis of the lesions which we have observed in our experiments on cerebral commotion in the motor regions of the cortex, and in general in the motor centres and tracts, have shown in a conclusive manner that they manifest themselves in a perfectly constant and characteristic manner.

1. If the lesion is slight, like a superficial extravasation, an *exaltation* of the function of these centres is observed, *i.e.* muscular spasms perfectly *localised*, and corresponding to the muscular groups over which the centres preside.

2. If the lesion is deeper, if it is *destructive*, there is from the first a *localised* paralysis, the counterpart of the spasm. The greater the destruction of the centres, the more extensive the paralysis; if the whole motor region is destroyed, there is complete paralysis of the opposite side.

3. A grand generalisation may be made—viz. that *lesions of the cortex* always cause functional disorders on the *opposite side of the body.*

(B.) But, frequently, on the following days (at the earliest, twenty-four hours) *contractures* appear. This is a *secondary* symptom.

This contracture is diffuse *from its first appearance.* It appears limited to the muscles on the corresponding side, but soon becomes generalised, and affects both sides of the body.

It is not constantly more marked on the opposite side. Most account for this secondary contracture by irritation at a distance, the mechanism of which they do not explain. Others think it is the result of the extension of congestion and inflammation over the whole surface of the hemisphere where the lesion is situated, and sometimes to the opposite hemisphere. Some believe that the inflammatory action extends to the base and irritates excitable regions—such as the cerebral peduncles, bulb, or the cord itself.

Post-mortem examination does not always substantiate these suppositions. One does not find, on autopsy, this extension of inflammatory congestion or other forms of lesion over the whole hemisphere, or to the base, or to the opposite hemisphere. In my opinion the secondary contractures consecutive to lesions of the convexity of the hemispheres, are the result of irritation of the nerves of the dura mater. They are *reflex contractures.* Let us now prove this proposition.

1°. Certain physiological considerations favour this view. Mechanical, chemical, or physical stimulation of purely motor nerves, causes spasms in the muscles in which they distribute themselves; but these stimulations must be more intense and more prolonged in order to cause a true tetanus of the limb. On the other hand, irritation of sensory nerves, or of the central end of mixed nerves, much more easily and more rapidly provoke reflex spasms, which spread, first to the muscles of the opposite side, and then to the whole body; and also easily keep the muscles in permanent contraction or tetanus.[1]

When a purely motor nerve, such as the facial, is the seat of disease, it is rare to observe veritable contractures, except in acute inflammations. More frequently paralysis results. Thus in caries of the petrous portion of the temporal the first signs of the extension of inflammatory processes are fibrillary contractures, spasms, and lastly paralyses. Contractures of the face, on the contrary, occur most frequently under the influence of irritation of branches of the trigeminal, by superficial lesion of the buccal or conjunctival mucous membrane, or by slight incisions of the skin. Feeble electric stimulation of

[1] Experiments, particularly of Eckhard and Kühne.

the cortex causes localised contraction of the corresponding muscles; if it is stronger, it causes epileptiform convulsions—*i.e.* the spasms spread, but the tetanism or contracture does not occur unless the current is so intense as to spread, as I have shown, to the sensory structures of the base. Also mechanical irritation caused by superficial extravasations on the cortical motor region, pyramids, and motor regions of the fourth ventricle, cause perfectly localised contractions. On the other hand, mechanical irritation of the restiform body, of the nerves of the dura mater, or of the posterior columns, causes diffuse spasms, which rapidly become general, and which, if the irritation increases, pass into contractures or tetanism.

It follows from these considerations, that lesions of the motor regions, centres or conductors, manifest themselves by localised muscular contractions, by general spasms, under the form of epileptic attacks, or by paralyses. Lesions of the sensory fibres manifest themselves in pain, hyperæsthesia, anæsthesia, or in *reflex motor* phenomena, *i.e.* contractures or tetanic spasms.[1]

2°. The nerves of the dura mater are very sensitive; they have, as we have seen, a *great reflecto-motor power*. Why not attribute to them the principal rôle in the secondary contractures which supervene on injuries of the cortex? They possess in a high degree the qualities requisite for the production of these secondary effects. On the other hand, the grey matter, under conditions of exact experiment, does not react except by contractions (*secousses*); its destruction causes localised paralyses. The cortical symptoms are always localised; the contractures are mostly diffuse and invading.

3°. Lesions of the cortex are always crossed; destruction on the right, paralysis on the left. On the contrary, the contractures which accompany cortical lesions, occur sometimes

[1] It may perhaps be objected that chronic lesions confined to the motor tracts, cause permanent contractures. But actually these contractures, in descending sclerosis, appear *slowly*, long after the paralysis, and it is possible that they are due to extension of the inflammatory process to *sensory regions*. MM. Charcot and Pierret have demonstrated many cases of the propagation transversely of systematic lesions, particularly in locomotor ataxy. On the other hand, would it not be strange to regard lesions, the *most destructive*, of the motor strands, as the cause of exaltation of the functions of these strands?

on the one side, sometimes on the other, without any degree of constancy.[1]

4°. It is further to be added that lesions *really central*, such as lesions of the centrum ovale, situated at a distance from the dura mater, are rarely followed by early rigidity, as Charcot recently observed in a discussion at the Société Anatomique. Contractures probably do not occur in cases of central lesion, unless sensory fibres are excited, either directly or indirectly, by the mechanical action of hæmorrhagic foci. So, perhaps, lesions of the posterior part of the peduncular expansion (in which Veyssières, Raymond, Carville and I have demonstrated the existence of sensory fibres, section of which causes crossed hemianæsthesia) are capable of causing this contracture. On the contrary, superficial lesions, close therefore to the dura mater, and in particular congestive lesions, are almost always accompanied by contractures.

Their action is analogous to that of congestive lesions of the conjunctiva, which so readily excite spasm in the eyelids, face, or oculo-motor muscles.—Render the globe immovable by keeping both eyes closed by soft compression with wool, and the pain and contractures cease. This analogy is the more justifiable since the hemispheres, like the eyeballs, are subject to constant expansions and contractions, and rub continually on the inner surface of the dura mater. Render the hemisphere immovable by compression, as I have frequently done; and, unless the lesions extend to the base, no contracture supervenes.

(C.) These physiological considerations nevertheless, however important they may seem, require to be supported by actual proofs. Since the nerves of the dura mater have, as we have said, this property of causing contractures, this must be proved by showing that these contractures do not occur when the dura mater is rendered insensible. Two methods of procedure suggest themselves: (1) to cut the trigeminus at its root;

[1] I do not think that it can be laid down as a rule that the contractures which depend on irritation of the dura appear constantly on the same side, while the *so called* contractures of cortical origin occur on the opposite side, in the limbs primarily paralysed; for irritation often causes crossed action, and it frequently happens when the nerves are pinched between the forceps that the spasms become general, or even occur primarily on the opposite side.

(2) to resect a large portion of the dura mater, and see if the cortical lesions still cause contractures. I have not attempted the first method, because section of the trigeminus is a very delicate operation, and difficult to carry out without causing lesions of the base, which might themselves cause contractures. I have therefore employed exclusively the method of resection of the dura mater over a large area. In no case in which this operation has been performed have I seen contractures occur, so long as the cortical lesion did not extend beyond the portion uncovered, or towards the base, or to the opposite hemisphere. The following is an observation of this kind.

Exp. LXIII.—*Opening of the skull and resection of the dura mater over a large area.—Fixation of the brain by a plate of cork.—Phenomena of encephalitis without contracture.—Observation for twenty-one days.—At the autopsy, destruction, by encephalitis of a large portion of the hemisphere—the motor regions destroyed.*

[Details omitted.]

In this experiment I resected the dura mater, and introduced a plate of cork within the cranium, causing gentle compression, so as to fix the hemisphere. During the twenty-one days of the animal's survival, under constant observation, encephalitis progressed slowly over the whole convexity of the hemisphere, and yet at no period did contracture occur. It is not, however, necessary to resect the dura mater, as fixation of the hemisphere by moderate compression is enough to prevent contracture, notwithstanding the occurrence of encephalitis. Of this the following experiment is an instance.

Exp. LXIV.—*Compression of the left hemisphere by a plate of cork.—Localised meningitis.—Absence of contracture.—Death.*

[Details omitted.]

This experiment proves, therefore, that when the cerebral hemisphere is rendered immovable, encephalitis may appear and go through all its phases, without contracture occurring. In this case the nerves of the dura mater were compressed.

But this matters little in reference to the demonstration which will be given.[1]

The absence of contracture is also observable in the following experiment, and in several already detailed.

Exp. LXV.—*Depression of the skull on the left side.—Meningitis. —Absence of contracture.—Recovery.*

[Details omitted.]

In the cases in which, in consequence of this compression, instead of a superficial encephalitis, a diffuse phlegmonous meningitis occurs, the contracture does not show itself till late, and when the lesion has extended to the base.

When irritating injections are made into the cavity of the arachnoid, the assemblage of symptoms is very different. There are at the same time contractures dependent on irritation of the nerves of the dura mater, and paralysis due to destructive lesions of the cortex.

Exp. LXVI.—*Injection of iodine into the cavity of the arachnoid. —Contractures and paralyses.—Pachymeningitis and destruction of the cerebral cortex.*

[Details omitted.]

Remarks.—This experiment is complex. Nevertheless, with what has already been acquired, we may analyse the groups of symptoms.

1. At first, at the moment of injection, there were phenomena of shock: viz., contraction of the limbs, ocular spasms, opisthotonus, arrest of respiration, &c. Six grammes of iodine injected with sufficient rapidity into the cranium, are therefore sufficient to produce these symptoms. The shock was of

[1] Resection of the dura mater seems to have a notable influence on the progress of the lesions. In observation LXV., it is to be remarked that after resection of the dura mater, contracture did not supervene, until the meningitis of the convexity had ceased, and the animal had completely recovered. This is not surprising, as it is known that the nerves of the dura mater are excito-motor of the vessels of the brain, and that they keep up congestion. This is an important fact, for it seems as if resection of the dura mater had an influence on the circulatory disturbances which accompany cerebral traumatisms.

short duration. Observe, however, that at the moment of injection, the contracture occurred first on the same side, and it was not for several moments after that general opisthotonus occurred. Perhaps this first phase of the contraction may be attributed to irritation of the nerves of the dura mater.

2. To the irritation of the dura mater is further to be ascribed the slight rigidity which a few minutes after the injection occurred on the right side, and also the contraction of the pupils, more marked on the right (side of injection).

3. On the contrary, the paresis of the whole left side, observed in the evening, was doubtless caused by the encephalitis of the cortex. This, as is known, has crossed action; hence paresis on the left side with encephalitic softening of the right hemisphere. The paralysis was not complete, because the cortex was only partially affected.

4. In the second period, what was the cause of the ocular convulsion? Is it a reflex phenomenon due to irritation of the nerves of the dura mater? Or is it the effect of paralysis of one of the muscles of the eyeball; paralysis caused by lesion of the posterior ocular centres of the cortex?

I am not the first to attribute the contractures seen in connection with cortical lesions to the dura mater.

Marshall Hall held the same opinion, but he brought no proof in support of his theory.

Brown-Séquard, with his accustomed genius, has long held that the phenomena which ensue on cerebral lesions are either phenomena of irritation at a distance, or paralytic phenomena. I do not understand why this celebrated physiologist, one of the pioneers of nerve pathology, has not pursued his theory and investigated the mechanism of this irritation at a distance, which consists almost always in reflex spasms and contractures.

The investigation which I have made invalidates all the more the criticisms he has lately urged against the theory of cerebral localisation. In reading his last paper in the *Archives de Physiologie*, it is easy to see that many of the cases he cites against the localisation theory are phenomena of irritation at a distance, as he still terms it, and consist in contractures hardly localised or plainly diffused. The only *troubles de*

diffusion which can be admitted, in my opinion, are the result, either of the propagation of the irritation of one motor centre of the cortex to neighbouring ones, or of the propagation by means of the fibres of the centrum ovale to the bulbo-medullary centres.

It is thus that Ferrier, Carville, and I have produced generalised epileptiform convulsions by strong and long-continued irritation of one cortical centre.[1]

The more recent researches of M. Pitres on the experimental induction of epilepsy, place beyond all doubt the propagation of irritation of the cortex to the bulbo-medullary centres, through the medium of the medullary fibres.

There exist therefore three principal modes of production of motor symptoms, by irritative lesion of the nerve centres:

1. Direct local irritation of the motor centres themselves, mechanical or pathological (small hæmorrhages on the surface, but not destroying the motor regions).

2. Secondary effects, by *irritation at a distance*, of the bulbo-medullary centres, by means of the sensory nerves of the dura mater, or other sensory parts of the hemispheres (posterior part of the internal capsule, sensory tracts or postero-superior parts of the peduncles or pons, sensory nerves at the base, restiform bodies of the medulla, posterior columns and posterior roots of the spinal cord).

3. By extension of the irritation of a cortical motor centre to others in the vicinity, or to the bulbo-medullary centres through the motor medullary fibres of the hemispheres. These last consist always in epileptiform attacks, which commence most commonly in the muscles corresponding to the centre first affected.

In his unpublished lectures, M. Charcot has already indicated these modes of causation of nervous symptoms. He suspects the influence of the nerves of the dura mater in *irritation at a distance*, but has no positive facts to give in support of this theory. He indicates very precisely the genesis of epileptiform attacks.

[1] This is another fact to prove that the cortical centres do not manifest their lesions except in muscular spasms, in cases of irritation, and in paralysis in cases of destruction.

Résumé.

The dura mater contains sensory nerves eminently excitable.

I. As is the case with all sensory nerves perhaps, irritative lesions of these nerves cause: (1) pain, hyperæsthesia, neuralgia, and reflex motor phenomena; (2) reflex spasms or contractures of the muscles of animal and organic life.

(A.) The spasms or contractures of the muscles of animal life may occur in the face, eyeballs, neck, trunk, or limbs. They occur sometimes on the one side, sometimes on the other.[1] These symptoms tend to diffuse and invade neighbouring groups of muscles.[2] They have never the localisation, the measured and purposed character of the contractions which belong to lesions of the cortex. They frequently become transformed into permanent contractures.

(B.) The reflex vaso-motor disturbances, due to irritation of the nerves of the dura mater, consist in spasms or congestive paralyses of the cerebral and ocular vessels, either on the same or the opposite side.

These facts are important to pathologists as they show the great influence of irritation of the nerves of the dura mater on cerebral vascular conditions, and on the organs of sense, and on the causation of secondary effects in cerebral traumatism, *i.e.* on the congestions and inflammations of the cerebral membranes.[3]

II. Destructive lesions cause local anæsthesia of the dura mater.

[1] M. Vulpian has demonstrated, in his *Physiology of the Nervous System*, that centripetal excitations do not constantly decussate in the medulla.

[2] It is known that in certain cases the contractures diminish during sleep, and become intensified during waking hours, and under the influence of sensory stimulation.

[3] Up to the present we know nothing of sensory nerves in the pia mater. During irritation of this membrane by puncture, tearing, &c., animals exhibit no signs of pain. It is however, very different, as we have shown, in regard to the dura mater. It is probable, however, that in the pia mater there are reflex vaso-motor nerves. We have described, according to Purkinje and Kölliker, the nerves which accompany the blood-vessels into the nerve tissue, but their physiological action is little known.

ON SOME SYMPTOMS OF ORGANIC BRAIN DISEASE.

BY W. R. GOWERS, M.D.

Assistant-Professor of Clinical Medicine in University College, Assistant-Physician to the National Hospital for the Paralysed and Epileptic.

I.—On Sudden Paralysis in Cerebral Tumour.

Paralysis, the result of the presence of a growth in the brain, is commonly of slow, gradual development. Such paralysis is rightly regarded as characteristic of tumour. Loss of power of sudden onset is sometimes regarded as incompatible with the diagnosis of a growth. But this is certainly incorrect. Cerebral tumour is occasionally associated with paralysis of onset as sudden as is ordinarily thought to be characteristic only of hæmorrhage or softening. In some cases this sudden paralysis is not due to the tumour—it is due to an associated vascular lesion. But in other cases such associated cause cannot be found, and the sudden paralysis appears to be the direct effect of the growth. These cases are of much pathological interest, and all are of clinical importance on account of possible errors in diagnosis. There is nothing new in the fact, but it has scarcely received the attention it deserves.

In speaking of sudden paralysis, the cases may be distinguished in which the onset of the paralysis is accompanied by a convulsion. It is very common for a convulsive attack to leave considerable weakness in the part convulsed. After an epileptic fit such weakness is transient. After a convulsion from organic disease, as tumour, it may be permanent. It is, in that case, the result of the presence of the growth

in a motor region, which means the irritative destruction of that region. The weakness resulting from the after-effects of the "discharge" may render the effect of the graver damage produced by the growth suddenly apparent. But these cases, although they may be distinguished, cannot be entirely separated from those in which the paralysis results suddenly from the direct action of the growth without convulsion.

The causes of paralysis of sudden onset in cerebral tumour may be enumerated as follows:—

Associated conditions .	Hæmorrhage into and around growth.
	Softening from (*a*) associated vascular disease.
	(*b*) Pressure on or Invasion of vessels.
Direct effects . . .	Inhibition (?)
	Exhaustion from convulsion.

The first-mentioned cause, hæmorrhage, with growth, is one of the rarest. The condition is common, but does not occur, as a rule, until the tumour is of considerable size. The resulting hæmorrhage does not produce paralysis unless the tumour is situated in a motor region; but the growth so situated has commonly caused paralysis from its size, before the hæmorrhage occurred.

Softening, from direct invasion, and consequent obstruction, of vessel, artery or vein, is also rare. It is well known how constantly vessels escape the effects of pressure or invasion by such growths as occur within the skull.

Softening from associated and independent vascular disease is, however, a common incident in cerebral tumour. It may occur in the old, in whom chronic endarteritic changes occasionally co-exist with a growth. It occurs, however, more frequently in the young, in cases of syphilitic disease. It is exceedingly common for syphilitic disease of vessels and a syphilitic growth independently of vessels to co-exist, and each may produce its own symptoms; if the tumour is not in a motor region, there may be only headache and optic neuritis to declare it, and the only paralytic symptoms may be due to the vascular disease, and may be of instantaneous onset. The following case is an instance of the co-existence of these two conditions, and in it the sudden paralysis must, I think,

be ascribed to the vascular disease. The case is also of interest from the long interval between the primary syphilis and its latest manifestation.

T. N., a strongly-built artisan, aged 35, was first seen at the National Hospital for the Paralysed and Epileptic, on May 30. He was suffering from slight right hemiplegia, and gave the following history. Fifteen years before, he had well-marked constitutional syphilis. Four years before, after having pain in the back of his head for some weeks, he had what his wife termed a "fit," in which there was loss of consciousness for a few minutes, but no convulsion. It was followed by slight right-sided weakness, which lasted for some months, and then gradually passed away. The headache, however, continued, and he had occasional attacks of giddiness, in which he walked unsteadily. A year after the first, a second similar attack of loss of consciousness left him slightly weak on the right side, as did the other, but was succeeded by total, or almost total, loss of sight. He could see perfectly until the occurrence of the loss of consciousness. After four months' blindness, the sight gradually returned, but not completely. The giddiness became less marked, but the occipital headache continued until a year ago. He was pretty well until a fortnight before he came under observation, and then two convulsive attacks occurred, apparently general. After the last, control was lost over the bladder and rectum.

When first seen he seemed to understand slowly what was said to him. The expression of the face was dull and heavy. He did not speak, except when asked questions, and then sometimes remained silent and looked puzzled, at others answered them intelligibly, speaking slowly. No paralysis could be detected, either in the limbs or of any cranial nerve; but the stools and urine were passed involuntarily. Ophthalmoscopic examination showed the right optic disc to be well coloured, but clear, outline distinct; around it, however, were several white patches with soft-looking edges, over which the vessels of the retina passed without change of position or calibre. The vessels were normal. Examination of the left eye was impracticable, on account of an old injury.

Under the influence of perchloride of mercury he improved

rapidly. In a few weeks he regained control over his sphincters, and spoke in his ordinary manner. On July 1, however, he complained of general malaise, but had no headache or giddiness. Next day his wife observed his manner to be strange. On July 3, he was drowsy, sleeping most of the day; his manner was dull and listless. He spoke as usual when asked questions, but did not care to speak unless spoken to. On the following morning, July 4, his wife, on waking, found him unable to speak or to move his right arm or leg. She had noticed nothing like a convulsion in the night, and thought that she must have done so had there been one. He could not open his mouth farther than would admit the tip of a spoon, but seemed to swallow liquids without much difficulty. Next day he seemed to notice what was going on, and after a few days to understand what was said to him, but he did not speak, except that when pressed by his wife to say if he was better, he said "Better."

He was seen on July the 10th; he seemed to understand whatever was said to him, and attempted to execute any movement he was told. He could not be made to say "Yes" or "No" voluntarily. Once he uttered correctly two or three words in answer to a question. No other speech could be obtained. There was very slight paralysis of the lower part of the face on the right side, noticeable at rest and on slight movement, but disappearing on stronger movement. He could not be made to protrude his tongue, nor to contract his masseters. No paralysis of any other cranial nerve could be detected. He could not move his right arm or leg. By a strong effort to move the leg he could just contract the muscles of the right thigh. The limbs were not rigid. There was distinct hyperæsthesia of the paralysed arm and leg. Ophthalmoscopic appearances were unchanged.

In this state he continued for three days; and then, on July 14, violent convulsions came on, and recurred so frequently that his wife described them as "one continuous fit." Both sides, according to her account, were equally involved in the convulsion, both arms being very rigid. The attacks continued until his death, four days later (July 18).

At the post-mortem examination a small growth was found

in each hemisphere. That in the right hemisphere was about the size of a cherry, and situated in the lowest portion of the parietal lobe, in the supramarginal gyrus, above the posterior limb of the fissure of Sylvius. It reached but did not project from the surface of the convolution. On section it was firm, and the cut surface was uniform, greyish, and semi-translucent.

In the left hemisphere a tumour the size of a walnut existed in the inner part of the frontal lobe, about two inches from the anterior extremity of the hemisphere. It involved the grey matter of the marginal convolution, but was elsewhere situated only in the white substance of the hemisphere, which was much softened, and mottled with vessels in the vicinity of the tumour. Its surface was greyish red and translucent. On section it was very firm, having nearly the consistence of soft cartilage. The greyish-red superficial layer enclosed a central opaque greenish-yellow mass. This "cheesy" centre was irregular in shape, irregularly lobulated, the portions being separated by reddish-grey translucent tissue, continuous with that of the periphery, but of a deeper red.

On slicing the hemisphere it was seen that while the posterior third above the ventricles was firm, and presented more visible vessels than normal, the anterior two-thirds were much softer than natural, and contained very few visible vessels. The softer portion was reddish in the neighbourhood of the tumour, white in the middle of the softened portion, and yellowish behind. The walls of the lateral ventricles were quite firm. The corpus striatum and optic thalamus were perfectly healthy. The cerebellum was free from any abnormal appearance.

The vessels at the base of the brain were diseased at several points. On the left vertebral, on the side of the medulla oblongata, was a semi-opaque swelling, about half an inch in length, and in thickness about equal to the diameter of the artery. On section the thickening had only slightly diminished the calibre of the vessel. The right vertebral was larger than the left, and tortuous. The branch of the posterior inferior cerebellar artery, which runs along the anterior edge of the cerebellum, also presented a large nodule, the size of half a pea, semi-opaque, and similar in appearance to the other, and,

like it, not obliterating the artery. Another nodule of similar appearance lay in the middle of the left Sylvian fissure, being attached to the most anterior of the two arteries, into which the middle cerebral divides, and this part of the vessel was closed. Branches of the other unaffected artery, given off further on, could be seen passing onwards and forwards over part of the nodule to supply the contiguous brain substance, which presented no trace of softening.

I think that the anæmia and softening of the anterior part of the left hemisphere must be regarded as the cause of the sudden paralysis and loss of speech, and that this anæmia must be ascribed to the co-existing disease of the middle cerebral artery. No symptoms can be ascribed with certainty to the growth in the right supramarginal gyrus. The sight of the opposite eye had been long lost from injury.

There remain for consideration the still more interesting cases in which a cerebral tumour causes a sudden paralysis without there being any discoverable cause for the suddenness of the onset. Of this the following cases are examples :—

A woman, aged 53, had been suffering for about six months from headache and rheumatic pains in the chest. Twelve days before, she suddenly fell while walking, but without, according to her own account, any loss of consciousness or any giddiness. For the next seven days there was more headache and irritability, but no weakness. Then, five days before admission, she lost consciousness for three hours, and on recovering consciousness was unable to move the left arm or leg, without, however, any affection of speech. Gradually her mental state became more and more dull. When admitted into the National Hospital for the Paralysed and Epileptic, there was complete left hemiplegia and great mental dulness. She lay on her back taking no notice, making no attempt to change her position, moaning frequently. When spoken to she would not at first answer, but on the question being repeated, especially if simple (as the names of her children), she answered, commonly correctly. After one reply, it was difficult to extract another for some time. She lay in bed with head and eyes inclined a little to the right (towards a window), but they

could be turned to the left freely. There was no other affection of ocular movements. The left side of the face was distinctly weak in the lower part. There was no apparent deafness. Deglutition was unimpaired. The tongue on protrusion deviated slightly to the left.

The left arm was absolutely paralysed and slightly rigid; the rigidity increased on attempts at passive motion. The left leg was also motionless. Sensation on left side was thought to be unimpaired. The right limbs were moved freely.

A few days after admission, the right arm and leg were moved less, and gradually became motionless. Soon after the right side became powerless, the mental state became more and more dull, and she passed into a state of insensibility, lying with eyes closed and mouth open, but occasionally half opening her eyes for a short time. Nothing roused her; but if the left arm was moved, an expression of pain passed over the face. Deglutition became difficult, partly at least from her mental state, food being held in the mouth a long time before being swallowed. The comatose condition increased, and she died a month after her admission—the temperature having been normal until the last day, when it rose to 102°.[1]

At the post-mortem examination, two growths were found in the brain; one, small in size, in the right corpus striatum, and a large one in the corpus callosum extending laterally into both hemispheres. The small growth measured three-quarters of an inch from before back, and five-eighths of an inch from above down. It was situated at the junction of the crus with the corpus striatum, its inner limit being just outside the optic tract, which was not, however, in any way damaged. It occupied the anterior and upper part of the radiation of the crus into the striate body. The larger growth had infiltrated the substance of the corpus callosum, so that its white substance was no longer distinguishable. Its antero-posterior extent was an inch and a quarter, the posterior extremity being two inches from the posterior extremity of the corpus callosum; the anterior margin of the growth was just behind, and did not involve the anterior curved portion of the corpus callosum. A few white

[1] The notes of the symptoms of this case were taken by Dr. W. A. Sturge.

longitudinal fibres were visible on the under surface only. On the upper surface it formed a grey prominence. In the left hemisphere it had infiltrated the white substance above the lateral ventricle, extending outwards as far as the junction of the latter with the corpus striatum, and almost to the grey substance at the bottom of the transverse frontal fissure; backwards as far as the level of the anterior extremity of the optic thalamus, and forwards as far as the level of the anterior extremity of the corpus striatum, infiltrating through this extent the white substance of the gyrus fornicatus, and to a less extent that of the marginal convolution; its anterior and vertical measurements being one inch and a quarter. In the right hemisphere its extent was smaller, its position being similar, but its antero-posterior extent only one inch, and its upper limit the calloso-marginal fissure.

The growths were uniformly soft, pinkish-grey, mottled with red dots and lines; nowhere opaque; uniform. Demarcation tolerably sharp; a little white softening outside the growth in the substance of the hemisphere. No hæmorrhage. The microscopical characters were, in each tumour, those of a glioma.

In this case we must associate the left hemiplegia with the growth in the right striate body, and the subsequent right hemiplegia, probably, with the extension into the left hemisphere of the tumour in the corpus callosum. There was nothing to account for the suddenness of the onset of the paralysis.

Another case, which I recorded a few years ago,[1] presents an equally striking case of sudden paralysis from tumour, and may be briefly recapitulated:—A man, while in fair health, lost consciousness for a short time, and afterwards slight persistent weakness of the right side was observed. Subsequently he had one or two other attacks of transient unconsciousness. Two months later he was one day found unconscious, and on recovering, in an hour or two, partial consciousness, the right arm and leg were found to be completely paralysed; he was speechless, and the action of the sphincters was involuntary. In a day or two he recovered slight power over the leg,

[1] *Path. Trans.*, vol. xxvii. p. 13.

and none over the arm. He became able to say a few words, stopping frequently from confusion, and being unable to get at the word he wanted to say. He could not name his occupation, but when it was mentioned he recognised it at once, and could then repeat the name. When he tried to speak quickly he became confused, mumbled, and could not be understood. This state continued for a fortnight. He then had a series of convulsions, epileptiform in the right side, with simultaneous co-ordinated movements in the left which struck the observers as undoubtedly "convulsive." He afterwards had fits confined to the right side, and the left limbs were motionless and apparently paralysed. Optic neuritis existed in the eyes. In this state he died. A tumour (glioma) was found in the left hemisphere, above the lateral ventricle, occupying the greater part of the superior parietal lobule, *i.e.* the parietal lobe above the intra-parietal sulcus. In the lower part of the lobule it projected above the adjacent convolutions in an area of about an inch. It extended downwards to within a quarter of an inch of the roof of the lateral ventricle, and inwards to within half an inch of the inner surface of the hemisphere. The upper extremity of the ascending parietal convolution was not involved, but was pressed upon, and narrowed by, the growth.

In this case also there was nothing to account for the sudden onset of the paralysis. In neither case was there, apparently, any initial convulsion. It is not conceivable that the sudden onset can have been the result of the pressure of the growth on, or invasion by it of, the motor tract, since such paralysis would be as gradual as the process which caused it. The sudden onset may be compared with another effect of tumour equally sudden, convulsion. Convulsion depends on the discharge of a motor centre under the irritating influence of the growth, and these facts seem to suggest that the irritation may exercise an influence on the centre, inhibiting instead of discharging it, or leading to the inhibition of the lower centres. This was the explanation suggested when the specimen from the latter case was shown (in 1875) at the Pathological Society, and in his lectures, since published, Dr. Brown-Séquard has applied a similar explanation very widely. As an

explanation of the phenomenon in question, it derives, I think, additional probability from the facts of the last case I have mentioned. In this, towards the last, there was a paralysis of the limbs on the left side as well as on the right. There was nothing to account for this but the growth in the left hemisphere: there was no evidence of any pressure exerted by it on the right hemisphere. The growth was situated in the midst of the fibres from the corpus callosum, and by its action on these may have exercised an inhibitory influence on the right centres, paralysing the left limbs. In the same manner a growth in this situation may cause, as in one case recorded,[1] convulsions beginning on the same side, in just the same manner as they had previously commenced on the opposite side.

Thus the phenomena of sudden paralysis after convulsion, and sudden paralysis without convulsion in cases of cerebral tumour, cannot be entirely separated, and the two may in some cases be conjoined as the result of the local irritation.

II.—On Slow Inco-ordination from Disease of the Optic Thalamus.

Many observations now attest the frequency with which lesions of the optic thalamus are associated with mobile spasm, spontaneous ("athetosis"), or in movement (slow inco-ordination). Charcot found disease of the white fibres outside the thalamus (posterior part of the internal capsule), and believed that it was the implication of these fibres which determined the symptom. In one case, however, in which jerky inco-ordination had been present, I found disease of the middle of the thalamus, not involving the capsule.[2] The following case is another illustration of the same condition: a spasmodic slow inco-ordination was due to a lesion nearly in the same situation.

Jane M., a married woman, aged 41, was admitted under my care into the National Hospital for Paralysis, in October, 1877,

[1] *British Medical Journal*, 1874. Dr. Buzzard, *Practitioner*, October, 1868.

[2] 'Athetosis and Post-hemiplegic Disorders of Movement,' *Med. Chir. Trans.* 1876.

with right hemiplegia of six months' duration. Its onset had been sudden, with transient loss of consciousness (for two or three minutes only). The attack had been preceded by much left-sided headache, frontal and occipital. A little "difficulty in getting words out" succeeded the onset: no more marked affection of speech. The arm and leg were powerless for months. She had considerable hypertrophy of the heart: no history of rheumatic fever. Owing to a mistake, her urine was not tested. On admission there was slight paralysis of the lower part of the face for emotional, none for voluntary, movements. The arm was still very weak, she could just raise the hand to the head, grasp = seven kilogrammes. The hand, when held out, was unsteady, and there was considerable irregularity in the movement of the fingers, causing slow inco-ordination, the fingers "sprawling" about. There was a little slow involuntary movement of the fingers. There was much spontaneous pain in the arm and hand. No change in sensibility was noted. A fortnight later the leg was stronger: she could walk alone, and was then sent to the country branch at Finchley. She was there found one morning unconscious. I saw her in the latter part of the day, and she was then lying on her back, incapable of being roused. There was no stertor, but a little froth was coming from her mouth. The left arm, when raised, was held for a moment, and fell gradually. The right arm and leg fell at once on being raised. When the right arm was pinched, it was moved a little. The conjunctivæ were sensitive. The eyelid closed when it was touched. The pupils were rather—not extremely—small: the left a little the larger of the two. The eyes did not quite correspond in position, and on close observation the right appeared to move while the left did not. There was no conjugate deviation. She died an hour later. From the inco-ordination of movement it was suggested that possibly the initial lesion was in the optic thalamus, and from the marked difference in the movement of the two eyes, that the ultimate lesion was in the pons. It proved to be so. A large clot lay in the substance of the pons, about the middle (from above down). It had destroyed the greater part of the left half of the pons, but many extravasations existed in the right half. The lowest

fibres (transverse) were little damaged: those from the anterior pyramids were wholly destroyed on the left side. The clot extended up to the lining membrane of the floor of the fourth ventricle just above the eminentia teres. The upper extremity was about a third of an inch from the posterior border of the corpora quadrigemina, and the lower at the level of the facial nuclei.

The left optic thalamus presented a depression on the upper surface running transversely across, in front of the posterior tubercle. On section a space was found, capable of holding half a nut, filled with ochre-yellow material, and situated nearly in the middle of the thalamus, passing inwards and backwards as far as the left anterior of the corpora quadrigemina, but in such a manner as to leave the posterior tubercle of the thalamus, and its connection with the corpora geniculata damaged. Externally it did not extend beyond the limits of the thalamus, but ended in a jagged border just to the inner side of the white bundles of the internal capsule. No other lesion could be found in the brain. The arteries of the base were normal, except the basilar, which presented some atheroma.

This case is of interest as showing, just as did the other to which I have referred, that inco-ordination of movement may result from a lesion of the optic thalamus itself, not apparently implicating the white fibres outside it. No defect of sensibility was noted; my brief notes of the case mention merely the absence of hyperæsthesia. There is some reason to regard the optic thalamus as both a sensory and a reflex centre. This function is quite in harmony with the circumstance that inco-ordination may result from the perversion or loss of its function. It is interesting to find that just as inco-ordination of movement of the legs results from damage to the tract in the cord through which the sensory fibres pass, and certainly without any correspondence with the affection of sensation, so inco-ordination seems to result from damage to the sensory ganglion of the brain, and, also, without relation to the degree of impairment of sensation. Of the cases of post-hemiplegic mobile spasm published in the paper before alluded to, six out of ten presented no impairment of sensibility.

ON BRAIN FORCING.

BY T. CLIFFORD ALLBUTT, M.A., M.D.

Physician to the Leeds Infirmary.

WHEN the Editors of 'BRAIN' sought my aid in the construction of this first number, I felt the honour they did me was not to be lightly refused; but, on the other hand, painfully aware that of late years my life had lain too much in the world to have led me to those results which are won by the patient labour of the student. From direct examination into the finer shapes of brain and nerve of late years I have become too much estranged; but I trust that observations in the field of practice may compensate, in some measure, the want of closer and more accurate research. On one subject I have long been fain to speak, for it is one in which I am exercised almost daily; moreover, I venture to hope it is not foreign to the purposes of this magazine. Almost daily I am in contention with parents and guardians, schoolmasters and schoolmistresses, clergymen and professors, youths and maidens, boys and girls, concerning the right way of building up the young brain, of ripening the adult brain, and of preserving the brain in age. Grievously ill do we take in hand to deal with this delicate member, and well is it that innate development overruns our schemes and brings the variety of natural good out of the monotony of human folly. It is dimly felt by society that the reign of bone and muscle is over, and that the reign of brain and nerve is taking its place. Even the Gibeonites now have the hydraulic ram and the steam felling-machine; the spectacled general of forces fights in his tent by click of battery and wire, and his lieutenant hoists an

ironclad by the touch of two buttons upon his waistcoat; the patient earth forgets the tread of horse and ox, and is ploughed by steam; and ere long, no doubt, our ministers will wind sermons out of barrel-organs, and our morning egg will be broken for us by a wafer of dynamite. Hence it comes that all classes are for "education!" The village grocer's son goes to a "theological college," and sits up by night over his "Evidences" with green tea in his blood and a wet cloth about his brows. The gardener's daughter pulls roses no more, and has become a pupil-teacher; she is chlorotic at sixteen, and broken-spirited at twenty. The country parson's son goes to a civil service or a navy "coach," is plucked in his teens, and is left to begin life again with an exhausted brain and an incurable megrim; nay, even the sons of Peers are putting on the armour of light, and are deserting the field for the counting-house. To meet this demand, colleges of all kinds and degrees spring up—middle-class seminaries, theological colleges, colleges of science, University boards;—even the old Universities themselves are stirring from their scholarly ease, are sending out missionaries *in partibus*, and are cramming the youth of twenty counties in the art of making most show with least learning. All this, in a way, no doubt, must be and should be; but so sudden a volte-face cannot be made without a wrench, and it is my desire now to see where the strain will tell, and how to perform our social evolution with the least injury to persons.

Like the vestryman of New York, who found it impossible to propose the paving of a street without allusion to the first lines of the Constitution of the United States, so I must venture to preface my essay by some reference to mental function as we find it. We may see the more clearly how to direct and combine our means of culture when we recognise its purposes. Mental philosophy is a subject in which I am little versed, but I must try in some familiar fashion to classify the aspects of nervous activity as they appear to ordinary observers. Without misleading error, and with much convenience, I may regard these activities from the following five points of view, namely, their Quality, their Quantity, their Tension, their Variety, and their Control.

By the higher quality of the brain or of a part of it, I mean that structure of cell and fibre which corresponds more widely or more intimately with outer conditions, so that by virtue of such relation the individual more readily apprehends things and conceives them. This is genius in the stricter sense. By quantity I mean the volume of nerve force given off by the brain or its parts without regard to quality of work done. By tension I mean the power in the nerve action to overcome inner or outer resistance—"nervous energy," as it is colloquially called. By variety I mean the congregation of different centres, and the weaving of mediate strands which give the possessor, not higher or wider, but a greater number of relations with outer things. In common life this is usually called versatility. By control I mean that subordination of one centre to another, whether inherited or acquired, which if of the lower to the higher results in obedience to the more permanent order of the universe. Thus a man may have a lofty, an abundant, an intense, a versatile, and a well-ruled nervous system, or he may have any measure of each of these states in various proportions. Goethe, whose life and character are so well known to us, seems to have possessed all these faculties in marvellous combination. His insight or brain quality was vast and penetrating; his stores of nervous energy were inexhaustible, burning with steadfast heat or flaming in passion; his faculties were infinite in variety, and they were under a control rarely in the world's history known to have harmonised endowments so manifold and so potent. To take in like manner a few more names by way of illustration, we may consider Lord Byron as one in whom quality and tension of nervous force were more remarkable than quantity, though this in him was not inconsiderable, and in whom variety was less manifest and control defective. Schiller again had high quality, tension and control, but was defective in endurance and in variety. In Keats we recognize quality, tension and variety in high degrees; control in less measure, and quantity in defect. His brain, inconstant in current, was worn out ere it was built up. Macaulay was, if the word be permitted to me, a remarkable "all-round" man, and presented an equable development of quality, quantity, tension, variety and control, though of course

he is not to be compared to the former examples in quality. Brougham had still less quality, but quantity in overflow and at high tension. Sir James Simpson again always seemed to me a good instance of a man lacking the higher complexities of brain, but abounding in mental force at high tension. In him also variety was striking, more striking than control. One of the most vivid instances of nervous energy at high tension to be found in modern history is perhaps Admiral Korniloff, as described by Mr. Kinglake, in the fourth volume of the cabinet edition of his *History of the Crimean War* (p. 108). He says of Korniloff: "It can hardly be shown that this chief was gifted with original genius, still less with piercing intellect; nor was Korniloff to be called precisely an enthusiast. Our knowledge of Korniloff must rest upon a perception of what people did when they felt the impulsion he gave. At a time when there seemed to be room but for despair and confusion, he took that ascendant which enabled him to bring the whole people in this place—inhabitants, soldiers, sailors—to his own heroic resolve. In a garrison town of an empire which had carried the mania of military organisation to the most preposterous lengths, all those straitened notions of rank and seniority and, in short, the whole network of the formalisms which might have been expected to hinder his command, flew away like chaff at the winnowing. By the fire of his spirit there was roused so great an energy on the part of thousands of men as has hardly been known in these times; and he so put his people in heart, that not only the depression created by defeat, but the sense of being abandoned and left for sacrifice by the evading army, was succeeded by a quick growth of warlike pride, by a wholesome ardour for the fight, by an orderly joyous activity." We may compare with this the description by the same fine hand of General Todleben, in whom quality and quantity of brain, variety of resource, and of smiling self-control, were all made efficient by high tension. Mr. Kinglake says, "Although Todleben seemed to be one to whom the very labours of fighting and of exterminating the weaker breeds of men must be an easy and delightful exertion of natural strength, he had joyous kind-looking eyes, almost ready to melt with good humour, and a

bearing and speech so frank and genial, strangers were instantly inclined to like, and very soon after to trust in him. From his looks and demeanour, it could not at all be inferred that he was a man who had devoted his mind to a science; nor imagine that his power of doing the right thing at the right time had been warped at all by long study of the engineering art." "Few men of great intellect have attained so closely what Englishmen mean by practical." How great quality and quantity of brain may fall short of achievement for lack of high tension rather than of control, must be sought in the story of Hamlet and like inventions, for, although the unhappy General Trochu is not yet quite forgotten, none such leave an enduring name. How many of us know that quiet friend unnoted of the many, unfelt by the world; whose powers of assimilating knowledge are great, whose intellect is capacious, and whose accomplishments are manifold, but whose nerve currents are of low or inconstant tension! He finishes no work, he fathoms no research, and he dies leaving but the memory of great powers wasted. Other curious instances of low tension are seen in those unhappy mortals, who conceive so truly, and have mental force in such quantity, that they spend their lives in bestowing volumes of good advice upon their fellows, but who never rouse themselves to their own work or duty. How, lastly, the greatest quality and capacity of mind, varied attainments and spiritual fire, may be spent as a sky-rocket is spent for lack of control and direction, has been the theme of moralists of all centuries, from the death of Abel to our own time. Of all endowments control is the most precious, and its nurture our most bounden duty. For a happy and useful life, perhaps control is more needful than quality, volume, variety or even tension of brain. But were not men born to us whose high qualities of brain enable them to see more deeply into the secrets of nature our progress would cease; did quantity of brain-force cease from a people, that people would lack endurance; were tension feeble, the lions would roar on in the paths of our enterprise; were self-control wanting, that which were won would hardly be won ere it was lost. Of all gifts then to be cherished and nurtured, perhaps we should place first control, as by it effort is

husbanded; perhaps of equal or scarcely of the second place comes tension; quality of brain cannot be had for the asking, and lack of quantity in individuals may be compensated by numbers. Variety, however charming, however grateful, is the least precious of these conditions of brain, and is the last which calls for nurture. How, then, are we so to wield our instruments of education as to promote the increase of control, tension and quantity without stifling quality and variety, and how are we to use these virtues in the riper man without disabling him?

Quality, as I have said, cannot be had for the asking, it is fitful in its growth, and often born out of due time. It should be favoured by the continuous inheritance of culture, but the mode of its epiphany lies in the same darkness with that developmental nisus which lies behind the advance of life upon the globe. Inherited, as it doubtless must be, yet its arising cannot be foreseen in the span of human generation. In the past it has more often burst forth from obscurity as the Greek and Arab from the Orient, the Roman from the Latin, the Pisan, the Genoese, the Venetian from Byzantium, the Tudor English from the England of Lancaster and Plantagenet. Men of high quality do not seem, even generally, to have sprung, like Pallas, from the brain of their fathers, but conceived in the dark womb of time to have lighted upon the world in companies. How then education, by taking thought unto itself, is to breed or make men of great initiative is a hard question. It seems clear, however, that it is not to be done simply by the wedding of brain to brain, but that for its generation may be needed some barbarous and even gross admixture, some strange coition between the sons of God and the daughters of men. But that which they who govern education can do, is to give to genius and to character a free way for expansion and action. We cannot make such a man as Edwards the naturalist of Banff, and the more sad is it that such men when born to us are too often maimed or driven by circumstance and their gifts despoiled. That many mute inglorious Miltons are buried in our churchyards, I venture to doubt; the fire of a Burns is not easily hidden under a bushel, but some smaller lights may thus be quenched, and the best of

such men, like Burns himself, may be thwarted or broken in heart. Some may aver, and not without seeming of truth, that trial is to genius as the furnace to noble metal. But surely, this world will always offer to its children a front stern enough for their chastisement, and a law hard enough for their contrition—there needs not the imposition of fetters of ours, nor the devices of our caprice or austerity. One born before his time, in the inertia of his own generation, will find resistance enough to try his steel. Moreover, as I have said, great quality of brain may not be associated to high tension, and a moderate resistance may be fatal to achievement. A man may not be a Luther, a Cromwell, or a Knox, but he may be a Melancthon, a Cranmer, or a Wishart, and in favouring days may do the work which was done by the former in virtue of high tension as well as of genius. It is too certain, on the other hand, that by stress of circumstance zeal may be turned into fierceness, reason into tyranny, and strength into brutality; it is well, therefore, we should see that in our scheme of education we are mindful of two things:—First, that we secure perfect freedom for the individual, and toleration for all opinions, and this must be done partly by the repeal of all legal privilege and partly by the gradual enlightenment of societies: secondly, that in our scheme of education we give the means of it to all, and full play to individual gifts —not promoting a dull uniformity, nor pinching back the buds of mental growth; nor, on the other hand, forgetting that as great men often appear in unpromising times, so great gifts in the individual are often long in showing themselves. The early dunce often ripens into the later genius. I find this late unfolding of greater gifts, though by no means universal or perhaps even general, yet is so common that as a teacher I have schooled myself into much sympathy with dunces. An observant master may detect the pushing germs beneath the immobile surface of his pupil's mind, but such masters are rare, and perhaps nothing is lost by leaving their quickening to kindly time. Our duty is meanwhile not to harass or exhaust the brain prematurely by anxious culture, by stimulant or by systematic forcing. Few men can look back upon their early companionships without seeing, with a feeling akin

to surprise, how the race has not always been to the swift, nor the battle to those who were strong.

"Another race hath been, and other palms are won."

Quality of brain, then, cannot be made nor forced; consisting, moreover, as it probably does, in added ganglionic and commissural structure, it, like all more complex growth, will be late in the bud and later in the bloom. And in pointing this out it must be remembered that we are speaking not only of the rarer forms of genius, but also of character—of that which gives to each person his individual colour and value. Quality of brain may, however, be lost if it is not invigorated and impelled by a strong breeze of nervous energy; nay, as in the case of the late Sir James Simpson, dauntless and inexhaustible nerve quantity may so elevate the spirit and so strengthen the hand as to clothe the individual with a power beside that of genius itself, and urge him to work which will win the undying gratitude of men. Now happily quantity, unlike quality, of brain force is much under the power of education. Quantity may be conceived as lying partly in the bulk of the nerve cells themselves, and partly in the volume of their vessels; partly also in the virtue of the blood itself. It cannot be forgotten that the health of the brain and nervous system, upon which the abundance of its fruit depends, is closely related to the tone and activity of the rest of the corporeal frame. The volume of force issuing from the brain is largely dependent, for example, upon the power of the stomach and allied viscera, upon the power of rapidly digesting and assimilating an abundance of food, and of breaking up and excreting spent material. A dyspeptic may well have nerve force of high quality, and of high tension; but I never met with a dyspeptic whose nerve force welled continuously forth. Like Brougham and Cavour, men of great power of continuous work have usually been large as well as sound eaters. A "hard-headed" man is also a hard-bodied man, and the national history of Europe is a long display of the successive triumphs of the men of colder over the men of warmer regions; of the hardy, lusty and hungry races over the softer, more indolent and more abstemious. Northern drunkenness is a survival of Northern feasting and Northern

prowess; and the hearty Bishop of Peterborough touched a deep truth when he said he had liefer Englishmen to be drunkards than slaves. It is quantity then, rather than other conditions of nerve power, which is favoured by "physical education," quantity without which quality may flag; but quality is also indirectly increased, for quality is born doubtless out of the fountains of quantity. If it be true that the sons of genius are often fools, the explanation may be that the parent has spent his great fortune of intellect and passion, and transmitted to his offspring a sapless and atonic brain. It may be true also that as from the lesser robustness of women the streams of vitality in them are more slender and less perennial, so the buddings of higher genius in them are fewer and less fertile. The weaving of the higher thought and emotion is found in our experience, even of individuals, to be especially exhausting, and apt, therefore, to alternate in its function with hours of indolence, and even of depression. The greatest master cannot be unconscious of these tides in his creative work, and the lesser, seeking relief and distraction between whiles, drifts into the "Bohemian." To secure then quantity of nerve force directly, and quality indirectly, the encouragement of bodily vigour and sturdy grain is fundamentally necessary. Without wealth of bone and blood volume of nerve force will dwindle, and the rarest quality may fail of proof, or lose its splendour. Before women can hope to do hard and high work, sense must expel sensibility, and school-girls must cease to walk out in a row, to veil their faces, to wear stays and to eat delicately.[1] Nay, if a certain ruggedness be not foreign to mental strength and growth, it may be that women, as a class, if they will excel in originality and endurance, must cease, as a class, to seek after the charms of daintiness and sentiment.

I am not therefore of those who think that the love of athletics is as yet in excess. Here and there men may expend in the hunting-field or on the river that which should have been given to their tripos, to their profession or to their country; yet this at worst is but an individual loss far out-

[1] In the Girls' High School at Leeds, a well-managed school in many respects, the girls are at work from breakfast to dinner and after dinner, with no interval for digestion, till four—for much of the year, that is, during all the daytime. Their cheeks know not wind nor sunshine.

weighed by the impulse given to the hardy, hungry vitality by which the nation thrives and its general volume of nervous force is augmented. Again, it is an old truth that in youth production and growth or development are in a measure opponent. The gardener, the stockbreeder, the trainer all know this and act upon the rule. The spontaneous and equable play of all sides of life favours growth and tone, but to enter the colt for the race, to bloom and seed the young plant or to put the young male to the stud is to stint their growth and to exhaust their vigour. Precocity is gained at the cost of feeble maturity and early decay. And yet can the young brain grow, cell add itself to cell, and fibre knit itself to fibre without work and play? Can the slack sinew be braced, or the muscle which is idle be increased? To this I would reply that the activity which feeds the waxing strand and ganglion is rather receptive than productive.[1] It is easy to forget how the child and the youth drink in knowledge and virtue imperceptibly as the green leaves spread themselves and feed upon the air. By an equable tide flowing in from every side, by the channels of the senses, by the universal surface of the skin, the inner chambers of the nervous system are expanded and stored with riches for future profusion. The mischief done daily by calling upon the unripe brain for productive work, for original composition,[2] for competitive examinations, for teaching, and even for preaching, is calamitous, and the evil is increasing. The impatient examinations of young children are as injurious and as foolish as the searching of the roots of the pushing plant. Cram again is that which secures the immediate production of brain results rather than the growth of the brain itself, and it must be thrusting itself upon the vision of all but the moon-struck, that young men who are prize-winners at the ages even of eighteen or twenty years have too often spent their brains before the natural yielding-time. Too often the star of his year is quenched ere his course be well begun, and if his life be not thenceforth a failure it may fall far short of its early promise,

[1] That receptiveness of brain, its play and its productiveness are but various degrees of function I do not forget, but few differences of degree are more clearly distinguishable.

[2] I believe in many schools mere children are ordered to write "original" essays on set subjects.

and the brain which might have been year by year more flexible, more potent and more enterprising is warped, stiffened and staled. Such young men are now sent into the world in numbers, with minds orderly, trim and garnished, but without *élan* and without initiative—admirable clerks and formalists—but as men of action spoiled for ever. Pupil teachers again present a curious subject for observation, and a sad one. Called upon as children to teach children, their brains turn backward, or stop at the stage they have attained, and the living stream of thought is congealed into a dead dogmatism. Their minds, no longer open to the dew of knowledge from above, are bent to the work of churning vapid juices for yet callower nurslings. Nor is this all: the striving and jaded brain sucks the kindly saps from the rest of the body, and the weaker sex more especially tend in their years of puberty to become pallid and enfeebled, or to break down altogether between the rival claims of mind and body. Other cases, of which my notebooks are full, are those in which brain power is run low in youth by the untimely pressure of business and of heavy responsibilities. A father dies, leaving his son, aged twenty or less, to carry on a large business, to pay his mother and sisters out of the concern, and to educate his younger brothers. Staunch to the backbone the lad throws himself ardently into life, carries at twenty years the burdens of forty, pushes onwards upon excitement and in ignorance of the mischief doing, labours for a few years or more according to his stores, and falls to pieces ere middle life is reached, and when his powers should be at their best. We label their cases "dyspepsia," "nervous debility," "mental disease," and the like: I refrain from giving scores of them. But most disastrous, perhaps, of all means of dissipating the stores of the unformed brain are the preaching tasks of the theological colleges, and especially of the Nonconformist colleges. These colleges are filled with young men—ambitious, of generous impulses and fervent temper; and their teachers, as seems curiously true of schoolmasters as a class, are utterly unconscious of the existence of the science of physiology. These hapless lads are not only spurred on to intense and prolonged study during the week, but are called upon to preach. I do

not mean that they are merely taught to use the voice and gesture which are the instruments of oratory, but they are actually set up to address congregations of people. I will say nothing of those hearers who find edification in the raw dogmatism of an undergraduate, or spiritual increase in the forced and jejune exhortations of striplings to whom spiritual experience is yet unknown; but I will say of the prentice preachers themselves that the system is immeasurably cruel. A luckless youth is forced to heat the yet empty chambers of his brain, and to forge false thunder therein at an age when he needs rather to sit at the feet of wisdom. Space forbids me to give instances from my books, but the facts are open to others as to myself. Men whose steps are faltering upon the very threshold of the ministry come to me lamenting that the hope and the fervour, the peace and the joy of their initiation have fled, and in their place are listlessness, weariness, confusion of mind—nay, even satiety and disgust. Their teachers urge them to drown their reaction in more work, and in unhealthy self-examinations. Pallid, dyspeptic, peevish, sleepless, disheartened, many of them creep into orders to come in later years to the physicians, almost cursing themselves because their labours are unfruitful, because they cannot sit down to think nor stand up to pray. The explanation is too clear. The brain has been forced, and has borne insipid fruit out of due season. It may never recover its tone, or recover it only after a long season of rest. It is sad to think how many young ministers have come to me alone with such a history—men otherwise of promise, but whose best efforts have been but as the crackling of thorns under the pot. We do not realize how long a time the exhausted brain takes to recover itself! A young physician may boldly tell the overtaxed merchant or student to take three months' rest; but probably three months must be added to that, and even six months again to the sum before any degree of stability is regained. It is nearly always true that a case of brain exhaustion needs what may seem a disproportionate time to get well. Repair in so delicate an organ is slow, and we know that gardeners and breeders would rather start afresh with young stock than nurse round specimens which have been checked. Yet Englishmen are coura-

geous and enduring, and many fight into the ministry without consciousness of harm. Nevertheless, I would ask concerning even these if there be found in them any lack of quick and exquisite thought, of keen and catholic vision, of deep and tender passion; or if there be in them any delight in phrases, and any shrinking from realities; any bondage to convention and prejudice, any blenching from the service of perfect freedom, whether the forcing and hustling of their brains in earlier life have not straitened their conceptions, and checked their mental sweetness, freshness and enterprise.

Another kind of premature brain forcing is seen in young artists. Young musicians, especially, abandon themselves with perfervid ingenuity, not merely to discipline and culture, but also to original composition and to excessive display. Hence, as the passion of music is of early manifestation, and the vanity of parents insatiable, we find the history of musicians is one long wail over brilliant promise and early exhaustion or death. It is as true of music as of every other art, that its greatest works are works not of youth but of manhood, not of tender age but of maturity. Schubert died at the age of 31, Mendelssohn at the age of 36, Mozart at the age of 36—these, like many other masters prodigiously, even wastefully, productive in the days of their spring, were worn out when their transcendent genius should have borne its harvest. Even in music we find the most lustrous and immortal works were the works not of youth, nor of early manhood, but of riper years; of masters who were endowed with inexhaustible wellsprings of force in body and brain, or who had husbanded their stores in earlier days. Handel composed his great oratorios after he had passed his fiftieth year. Sebastian Bach wrote the B Minor Mass at the age of 48, and the two Passions somewhat later still. Beethoven wrote the A Major Symphony and the Eroica between the ages of 34 and 44: he had thus reached formal excellence, and had he then died would, like Mendelssohn, have bequeathed a great name to posterity. Happily he lived on to write his grandest works, such as the Ninth Symphony and the Missa Solennis, after the age of 45. If we turn to our own day and regard the life of a genius who, in quality and quantity of brain-activity with

tremendous tension and infinite variety, occupies a position perhaps unique—I speak of Richard Wagner—we find he was born at Leipzig in the year 1813, and is now therefore 65 years of age, so that Lohengrin and the Ring des Nibelungen are the works of years more than mature. I will not pursue this argument with the other creative arts, nor stay to prove that works like the *Paradise Lost*, the *Divina Commedia*, and the *Tempest* are works not of youth but of age.[1]

I must pass on to consider brain work under the head of tension. Tension, I believe, depends in some way upon the tides of the blood-vessels—upon their rapidity perhaps—and more especially upon the rapid distribution of blood in particular directions. It may well be a matter of the nervi vasorum. Probably also some relation of capillary to cell, which favours rapid absorption, enters into the matter; for we see that tension diminishes with age—with the susceptibility of nerve and arteriole. It is a factor of infinite value to the man. "Learning," says Falstaff, "is a mere hoard of gold kept by a devil till sack commences it and sets it in act and use" (H. IV. B. iv. 3). We may regard tension under several aspects, as in the keen tenacity of intellectual work in such a master as Newton, when it is associated with lofty and powerful control; or again in vivacious temperaments where control is often less complete. In those "whom Englishmen delight to call practical" we see it associated with dexterity, with readiness of resource, and with keenness of the special senses. This invaluable attribute is happily much under the influence of education. Compare, for instance, the slow wit of the rustic with the mental alertness of the "joly prentis of Chepe." Education can not only instruct the mind, but can make it apprehensive, nimble and even fiery. "It is of no use to know a thing," we often say to our bedside

[1] The visitor who has lately returned from the magic show of Turner Drawings now in Bond Street, will doubtless remember Mr. Ruskin's words on the opening page of his Guide, wherein he says of Turner, "He produced no work of importance till he was past twenty,—working constantly, from the day he could hold a pencil, in steady studentship, with gradually increasing intelligence." Of the Master's work done between the ages of fifty-five and sixty-five, Mr. Ruskin says (p. 9), "In this period he produces his most wonderful work in his own special manner,—in the perfect pieces of it, insuperable." In the Slade School at Kensington subjects are given out for original work, a system which, in my judgment, is more likely to do harm than good.

students, "unless you can deliver yourself of your knowledge." The brain must not be a silent receptacle, but, to use the old phrase, must be a "copious promptuary" of learning and device. In this paragraph then we take not the contrary, but the converse of the former, and while remembering that quantity and quality of nerve force are diminished by calling upon the tender brain for production, tension, on the other hand, is promoted by busying the student with his work, and by stimulating him with a sense of his duties and of his just ambitions. Hence class tests and even class competitions and the due use of the spur are to be encouraged so far as they favour readiness, quick and accurate observation, and modest rivalries, but not so far as to call for "original compositions," for heated and straining effort, or for the rapid disgorgement of bolted and undigested bookwork. Tension then is an endowment of nature or is increased by education and example, and especially by the personal influence of an earnest and practical teacher, and by the informing of eye and hand rather than by the straining of thought and memory. Unlike quantity, tension is not immediately dependent upon physical health. Neuralgic and dyspeptic persons often possess this virtue in high degree, and indeed fasting is said by spiritual teachers to intensify mental action. If quantity, however, be not added to tension, great passion or great action is followed by utter exhaustion and depression; and where high mettle and enduring force are combined, we obtain the greatest results. Certain drugs, such as strychnine, have the property of heightening the tension of nerve, and others, such as iron and cod-liver oil, of enriching it in quantity. In the combination of the two kinds we have the most precious medicines. The so-called "nervous children"—products of a later civilisation—need especially the benefits of quantity and control, and intelligent parents secure this by restraining scholastic pressure, by enforcing a regular discipline, and by encouraging physical development.

That endowment which I have called Variety or versatility is also partly innate and partly acquired, but chiefly innate.[1] It must consist in the accretion of a greater number of ganglia

[1] Diderot is the most brilliant instance of the Various man I can at present call to mind.

and of interweaving fibres. This is not unfavourable to quantity of nerve force, but perhaps it is unfavourable to the quality or high development of special ganglionic groups, and also to tenacity or steadfast intensity. The schoolmaster therefore abhors versatility, and that greater schoolmaster, the world, grinds it to dust. Without variety the pedant loses the sense of the infinite interests and conditions of life; with variety and without penetration the *dilettante* is ignorant of the depths of his own ignorance. The pedant denies that any knowledge should be taken in small quantities, the *dilettante* is repelled by the isolation of limited research. It would seem to be the aim of good education to insist upon a mastery of one or more subjects, that the grown man should be able to fight with the foremost, to concentrate his powers and to realize what knowledge is, but that at the same time he should gain some not inadequate notion of the whole field of the battle of life. He will thus gain in sympathy and flexibility of mind, while he is saved from the "failing of omniscience." A happy citizen of the republic of learning must have culture at once liberal and profound, at once general and special; to such an one a little knowledge is no longer a dangerous thing.

Finally, Control is partly innate, but greatly the creature of education. It is, I believe, the earliest work of education, the safest work and the most abiding. As an innate virtue it consists, no doubt, in the superposition of more complex or higher centres upon the lower and upon the weaving of these together by commissures of various orders. These ganglia and fibres, sketched out as it were by inheritance, are nourished and developed by use, *i.e.* by education. By use lines of least resistance are established, and thus habits are formed. A man cannot bite his nails without fingers and teeth, nor can habits be formed in the mind without the pre-existence of conflicting ganglia, but it is infinitely important to test the child for their presence and to set up in them certain lines of movement, and certain coincident memories or "associations." Thus also appears the Will, that is the revelation to consciousness of the balancing of the faculties, though where consciousness enters, we know not, and shall never know on this side of the grave. No mistake, then, is more fatal than that of parents who let

children run wild on the pretence of physical development. This, indeed, they may obtain, and how guarded we are to be in forcing the brain I need not say again, but there can be no misfortune to a child greater than to escape the life of justice, order and rule, or to escape the training of those perceptions of social needs and social laws which when graven in our ganglia and long current in our nerves become habits of sympathy, charity and self-sacrifice. Herein I fear that the partisans of "secular" education are greatly at fault. Children may be trained in Board schools to habits of cleanliness and order, but they are not trained in the principles of liberty, nor are their eyes turned to the sanctions of religion. From this system I fear there may be a sad awakening for a coming generation. I may sum up thus :— The powers of the nervous system with which education is chiefly concerned are Quality, Quantity, Tension, Variety, and Control. Quality is beyond the direct efforts of education, its rarer development, both in nations and individuals, is as yet incalculable; in the early life of the individual it is often latent, and its greatest results belong to years of maturity. On the other hand education may often overlay it, thwart it or expend it, and as quality is largely dependent upon quantity or volume of nerve force, the ripening of those degrees of it which exist in ordinary men, and the favouring of those revelations of it which occur more rarely, are constantly prevented by brain forcing in early life. In men of great quality or genius such brain forcing has too often dimmed or blighted the splendour of their work, or has shortened their days, and has only failed to do so in others by virtue of their perennial springs of inward energy. Quantity therefore is a very fruitful possession, and, unlike quality, may be directly reinforced by wholesome conditions—by physical education, and by the promotion of healthy and rapid digestion, assimilation and excretion. Tension is a virtue without which quality and quantity of nerve force may be wasted. By it men overcome resistance, and are fired with impulse. Promptness, alertness and acute sense come also of this attribute. Tension may be increased greatly by education, and it springs up in the busier contentions of men. It is largely independent of physical

health and of food, but is favoured by action and the training of observation. Variety, by which men are enabled to touch the world at many points, can be favoured by education. If in excess it results in aimless dissipation of energy; if duly consorted with full knowledge of one or more subjects it gives breadth and flexibility to the intellect and promotes the happiness of personal and social life; it favours general progress by permitting the more rapid diffusion of the knowledge won by the few. Lastly, control is eminently a creature of education, and is perhaps the most precious gift of the individual man. Without justice, temperance and definite industry the most brilliant attributes of mind may be impotent for good, and without the habit of social subordination and the bond of social sympathy the most brilliant society would be but a rope of diamonds. Brain forcing is terribly mischievous. It urges genius into precocious fruitage, it drains the springs of nervous force, it excites high tension without giving volume to fortify it, it stints the variety of mental expansion, and by enforcing control it breaks the spirit. The true purpose of education is first of all to teach discipline—the discipline of the body, and the higher discipline of the mind and heart; to encourage the budding faculties to break freely in natural variety; to quicken the eye and the hand, and to touch the lips with fire; to promote the gathering of the fountains of vigorous life by fresh air, simple nutritious diet and physical exercise; and finally to watch for the growth, silent it may be for years, of the higher qualities of character, or even of genius, not forcing them into heated and froward activity, but rather restraining the temptation to early production, and waiting for the mellowness of time: remembering that the human mind is not an artificial structure, but a natural growth; irregular, nay, even inconsistent, as such growths are, wanting most often the symmetry and preciseness of artifice, but having the secret of permanence and adaptability. These words seem almost too simple—these truths too obvious for repetition, yet for lack of that which lies in them our modern schemes of education are day after day ruining the young by overstimulation and unhealthy competition. Happily the public is awaking to its error, and is beginning to regret the days when

its young dunces grew into its old heroes. What we did blindly in the past by trusting to the hidden wealth of nature, we may now do face to face by the revelation of her secrets.

P.S.—Since this essay was prepared for the printer, I have received the February number of the *Fortnightly Review*, which contains an article by Professor Huxley on Technical Education. In that article Mr. Huxley expresses opinions which must command general attention and adhesion. Although his argument is sped with thought and word far stronger and swifter than mine, and clothed with an authority to which I can lay no claim, yet I may perhaps without presumption call myself a fellow-labourer in the same field.

ON THE COMPARATIVE STRUCTURE OF THE CORTEX CEREBRI.

BY BEVAN LEWIS, F.R.M.S.,

Pathologist and Assistant Medical Officer to the West Riding Asylum.

A CONJOINT article by the writer and a fellow-worker in the field of cerebral histology was communicated last January to the Royal Society,[1] in which was given a detailed account of their researches into the intimate structure and lamination of a limited region of the cortex in the human brain. The region to which their enquiries had been limited was a large extent of that portion of the cortex which is regarded as *motor* by Ferrier. Since the former article was written, a further and more complete examination of the motor area in man, and the regions bordering upon it, has been made by the author of the present communication; and, further, the cortex of the motor area in the cat, and certain regions in the brain of the sheep, have been subjected to examination. It is proposed to give in these pages a résumé of the former paper, together with the results of later research.

Types of Structural Lamination.

Of the five distinct plans upon which the architecture of the cortex cerebri is framed according to Meynert, that lamination stated to be characteristic of the vault has been the subject of some dissension. Meynert[2] distinctly affirms that

[1] *Proceedings Roy. Soc.*, 'On the Cortical Lamination of the Motor Area of the Brain,' by Bevan Lewis and Henry Clarke.

[2] 'The Brain of Mammals,' by Theodore Meynert (Stricker's *Human and Comparative Histology*, vol. ii. p. 381).

this formation is five-laminated, in which statement he is supported by Mierzejewski[1] and Betz.[2] Baillarger[3] adopts a different view regarding the lamination typical of this region as consisting of six layers. Dr. Major[4] agrees with these views of Baillarger, and extends the limits of the six-laminated cortex to the central lobe or insula. Our researches, however, demonstrate that each of the disputants is correct only in a limited sense. There is a five and a six-laminated cortex, each typical of a certain definite area: but, whilst the six-layered formation is found extensively spread over the convolutions of the parietal and other regions, the *five-laminated* type is pre-eminently characteristic of the motor area of the brain. Another highly important feature of this region is the presence of large ganglionic cells which under the title of "giant cells" were made the subject of special attention by Professor Betz over three years ago.[5] Our examinations tend to convince us that these cells have a motor significance, and that in their configuration, size, and distribution, they present us with a thoroughly unique formation. These great elements are constituents of the fourth cortical layer; and as the question with regard to lamination centres around the mid-regions of the cortex, this fourth layer will necessarily share the larger amount of our attention.

Individual Layers in the Motor Area.

As regards the three upper layers described in detail in the original article, it may be briefly stated that the authors are at one with most observers. We, however, regard the cellular elements of the first layer as wholly non-nervous, and class them as connective and perivascular cells. The nerve cells of the second layer are continued in small numbers down through the whole depth of the subjacent stratum, the smaller pyramids lying side by side with the greater pyramidal cells of this

[1] 'Études sur les Lésions Cérébrales dans la Paralysie Générale,' *Archives de Physiol.*, 1875.

[2] 'Gehirncentra.' Betz, *Centralblatt f. d. Med. Wissensch.* Aug. 1874.

[3] Baillarger, 'Structure de la Couche Corticale.'

[4] 'Histology of the Island of Reil,' *West Riding Asylum Med. Reports*, vol. vi.

[5] Op. cit.

formation. The fourth layer was found to constitute a narrow belt, readily recognised in fresh sections as a pale white streak about midway down the cortex. In this layer we found the small angular cells described by Meynert scattered amongst a belt of large ganglionic cells. It is important to distinguish these angular elements from the small pyramidal bodies characteristic of the second layer for the following reason. It was stated above that these small pyramidal cells are found sparsely scattered through the whole depth of the third layer. Now, in certain regions of the brain these cells tend to aggregate towards the lower limits of the third layer, and eventually form betwixt it and the ganglionic series, a distinct and dense stratum of cells. Approaching closely as they do the neighbourhood of the true angular cells, and differing but slightly from them in dimensions, they may readily be confounded with them, unless attention be directed to the well-founded criterion given by Meynert, in referring to the angular elements as "rarely triangular or elongated in a direction parallel to the radial fasciculi."[1] In those portions of the ascending frontal, and first and second frontal convolutions which are *par excellence* supposed to possess motor endowments, we find the fourth layer consists of a belt of these angular elements, subdivided by the ganglionic series of cells; hence the latter have angular cells above, around, and below them. We have on this account felt disposed to term this fourth layer the mixed or ganglionic layer, as its order in cortical lamination varies in different regions, and hence the demand for a more distinctive term. We shall now proceed to a more minute inquiry into the general characters presented by the large ganglionic formation in these regions.

Ganglionic Cells of the Fourth Layer.

I. *Form.*—The pyramidal form is frequently seen, whilst a plump body elongated towards either pole, so as to approach somewhat the fusiform, is a very typical variety. On the other hand, the truly fusiform or bi-polar cell is rarely met with. The great irregularity in marginal conformation is attributable,

[1] Op. cit., p. 389.

in a great degree, to the extension of the protoplasm of the cell to some distance up the numerous branches. Each cell contains a large round or oval nucleus within which a nucleolus can always be demonstrated. These cells are peculiarly prone to pigmentation.

II. *Size.*—The measurement of a large number of these cells from a limited area on the ascending frontal gyrus gave an average length of 60 μ, an average diameter of 25 μ; the extremes being 30 μ and 96 μ for length, 12 μ and 45 μ for breadth. Taking a very large selection of cells from *various points* of this convolution, we found the average measurement to be 71 μ × 35 μ. The largest cell met with measured 126 μ × 55 μ.[1] The dimensions of the nucleus were 13 μ × 9 μ. (The *micromillimeter* (μ) = ·001 of a millimeter.)

III. *Processes.*—The average number of secondary processes was seven, the largest number fifteen.[2] Sections taken across the long axis of the cell exhibited the cell as the centre of an extensive area over which its branches spread, radiating outwards and downwards from all points of its margin. In these sections as many as eighteen branches might be detected occasionally. This being the mode of branching, it will be readily apparent that the absolute number of processes cannot be determined with any degree of certainty.

IV. *Distribution.*—The results of our examination on this point has been to demonstrate the very important fact that these ganglionic cells occupy certain *definite areas* remarkably constant in position; and it appears to us that these large *cell-groupings* are especially and exclusively a characteristic feature of the motor area, as defined by Ferrier. The authors do not question the fact that ganglionic cells of smaller size are found distributed over the cortex at a distance from this region of the motor centres; but we have never found in these latter realms the *large groups* or *distinct areas* to which we now draw attention. By means of the ether freezing microtome[3] we have been enabled to examine in rapid succession a great

[1] Betz gives as the size of these "giant pyramidal cells" 40μ to 120μ long, by 50μ to 60μ broad.

[2] This estimate exactly agrees with that of Betz.

[3] Vide *Journal of Anat. and Phys.*, April, 1877, and *Mo. Micros. Journal.*

number of sections from eight human brains in the fresh state, slicing the convolutions from end to end and examining the sections seriatim, and with the following results. The broad upper extremity of the ascending frontal convolution limited above by the longitudinal fissure, and below by the lower line of origin of the first frontal, was found to present two large groupings of these cells. (*See diagrams in the original article, loc. cit.*) The upper group corresponds to areas 2 and 4 in Ferrier's drawings;[1] the lower group, taking a position near the first frontal, corresponds closely to another motor area (No. 5 of Ferrier). In the sinuous portion of the ascending frontal, intervening between the origin of the upper and middle frontal gyri, there are two notable areas, the upper occupying the parietal aspect of the upper two-thirds of this region, the lower extending beyond the summit of the convolution towards the middle frontal. These two separate areas occupy approximately the circles 6 and 7 in Ferrier's figures.[2] Another very extensive group of cells occupy the posterior extremities of the two upper frontals.

To recapitulate, we have presented to us a series of distinct groupings of these great cells, arranged chiefly along the *parietal aspect* of the ascending frontal convolution, interrupted by two groups which occupy the *frontal aspect* at the origin of the superior and middle frontals, and which at these points run into an extensive area, disposed over the posterior third of the two latter convolutions. The cells are largest in those groups found at the upper end of the ascending frontal, and diminish in size toward the lower extremity of this convolution, as shown by the following table:

	Average Size of Ganglion Cells.	Largest Cell.
Left Ascending Frontal (upper extremity) ..	$60\mu \times 25\mu$	$90\mu \times 45\mu$
Upper Frontal (area at posterior end)	$45\mu \times 20\mu$	$69\mu \times 27\mu$
Left Ascending Frontal (lower extremity) ..	$35\mu \times 17\mu$	$41\mu \times 18\mu$

[1] 'The Functions of the Brain,' by Dr. Ferrier. Figs. 63 and 65.
[2] Op. cit. Figs. 63 and 65.

Thus, throughout the region examined, these cells form an *interrupted series*, differing essentially from the continuous layers above them; and the groups thus formed are distributed over certain areas, closely corresponding to several of the motor centres of Ferrier. Each group is subdivided into numerous secondary clusters of from two to five cells—the "nests" of Betz. The all-important fact to bear in mind with regard to these elements is their *interrupted distribution*, a feature which is still maintained in districts where their diminution in size no longer warrants our calling them "Giant cells."

In the lower third of the ascending frontal, from the origin of the middle to the inferior frontal gyrus, we recognise features approaching those presented by the ascending parietal convolution. No distinct areas of the ganglionic cells were observed, but these elements were more or less equally diffused in "nests" of small cells (35 μ × 17 μ to 41 μ × 18 μ) over the whole aspect of its fourth layer. I shall now proceed to enumerate the various points of interest afforded by my subsequent inquiries.

Regions Posterior to the Fissure of Rolando.

No *abrupt* passage from one form of cortical lamination to that of another is ever seen in the convolutions of the vault. Changes in type are gradually assumed, and no distinct boundary exists to indicate an exact line of demarcation. The structure peculiar to one region gradually fades and blends with arrangements which foreshadow the architecture of adjacent realms, and thus we obtain *transition regions*. The ascending parietal is such a transition region, where features characteristic of the frontal lobe are blended with those exhibiting a tendency to assume the laminar arrangements of convolutions posterior to it. By what arrangement of elements is this duplex character produced? In what respects does this region resemble the ordinary five-laminated type, and how does it diverge from the same? To reply to these questions, it is necessary to observe that the changes from the five-laminated type to that now about to be considered depend almost entirely upon alterations in the elements of the third and fourth layers. It is where these two layers approximate

Plate 1

Bevan Lewis

Section through Angular Gyrus - Human Brain
Illustrative of Lamination typical of Sensory Areas
As seen in Weid Cortical Regions

×145 diam.

that we observe those changes predominate which issue in a fresh grouping of constituent elements. In the fourth layer we still find in certain situations the large ganglionic cells so characteristic of the anterior half of the motor area. They are, however, very limited in number, and restricted within narrow bounds. They appear in sparse nests along the anterior aspect of the ascending parietal convolution, deep down in the fissure of Rolando, and are direct continuations of the groups found in adjacent portions of the ascending frontal. Far more numerous, and largest in size at the upper extremity of the gyrus, they become more thinly scattered below, and diminish in size, as do those in the ascending frontal convolution in its lower half. Throughout by far the larger extent of this convolution these great cells are not found, the fourth layer being here occupied by representative cells of much smaller dimensions. These smaller cells, however, resemble them in every respect exclusive of size, and are frequently arranged like them in clusters or nests. In the above-mentioned features this convolution *resembles* the ascending frontal—how does it diverge from it in structure? This is accomplished by the tendency to closer aggregation of the small pyramidal cell at the lowest stratum of the third layer. A numerical increase of these elements at the lower limits of the third layer goes on gradually augmenting from before backwards, so that we shall find a distinct layer has been added to the cortex betwixt the large pyramidals of the third, and the representative cells of the ganglionic series. (Plate 1.) We thus see that whilst the ascending parietal resembles the frontal convolutions in the presence of large ganglionic cells, and the nestlike arrangement of the smaller cells of the fourth layer, it diverges from it in its tendency to the acquirement of an additional series of small pyramidal elements between this layer and the third. Reference has already been made above to these small elements and their distinction from the angular cells of Meynert. It need only be added here, that in size, configuration, and branching they are exact representatives of the small pyramidal cells of the second layer. Such are the chief characters which stamp the ascending parietal convolution as transition ground betwixt a five and six laminated cortex. I will now endeavour to give

the remaining variations observed in this convolution, by describing separately each individual layer seriatim.

Lamination of Transition Realms between Motor and Sensory Areas.

(Plate 1.)

First Layer.—The characters of this layer do not differ from what have been noted in the frontal region. The cells are identical in size, structure, and aggregation. No other layer of the cortex of the vault presents more uniformity in structural details than this the most external of its layers.

Second Layer.—The cells are pyramidal or pyriform in contour, and give off from five to seven, or even more branches. They measure 8 μ × 6 μ, and have an oval or spheroidal nucleus, averaging 4 μ in diameter. In common with these smaller cells we also find a few larger elements, attaining dimensions of 13 μ × 9 μ, and possessing a nucleus of 6 μ diameter. A striking character, common to all these pyramidal elements, is the relatively large size borne by their nucleus to the protoplasm of the cell, as compared with the larger nerve-cells of subjacent layers.

The depth of this layer varies at different points, but an approximate average may be taken at ·186 of a millimeter at many portions, and especially near the summit of the gyrus the depth increases to ·279 of a millimeter. In the second frontal convolution the depth of this layer varies from ·139 to ·186 of a millimeter. It is a matter of difficulty to estimate with great exactitude the number and aggregation of these cells, but they are decidedly *more closely crowded* than in the ascending frontal convolution.

Third Layer.—The average depth of this layer is less than the corresponding formation in the frontal region, but less than in convolutions posterior to it. The greatest depth is attained near the upper extremity of the convolution on a level with the postero-parietal lobule. In the middle third of the gyrus this layer decreases greatly in depth, frequently measuring less than half the depth of this layer in the frontal region, but, towards the lower extremity, an increase in its depth is again observed. The average dimensions of the cells in the

upper half of the third layer is 15 μ × 11 μ, the nucleus measuring 7 μ in diameter. These cells gradually increase in dimension with their depth, so that in the lowest stratum they range from 32 μ × 18 μ to 34 μ × 26 μ. Reference to the table of measurements shows that these cells are decidedly larger than the corresponding cells in the ascending frontal and frontal gyri. As regards conformation and branches, the elements of both regions closely resemble each other. Comparison of sections from the ascending frontal and parietal demonstrate that these larger cells are far less numerous and more scattered in the latter than in the former region, whilst the small pyramidal cells, continuous throughout this layer, have greatly increased in numbers in the parietal region, forming here an important feature in the section.

To summarise then the distinctive features of this layer,—

1. Its depth is less than in regions anterior, and greater than in regions posterior to it.

2. Its large pyramidal cells are less numerous than in the frontal region, and are scattered in sparse groups at the lowest stratum of the layer.

3. There is a comparatively increased number of the small pyramidal cells through its whole depth which tend below to aggregate into a distinct layer between this and the ganglionic series.

Ganglionic Layer.—I have already anticipated above many of the results obtained with regard to the examination of this layer, and I shall therefore briefly summarise them as follows:—

1. The majority of the ganglionic cells form far less conspicuous objects than the corresponding series anterior to the fissure of Rolando.

2. The average dimensions attained by these cells were 37 μ × 21 μ, with a nucleus of 9 μ in diameter.

3. Large ganglionic cells rivalling those found in the ascending frontal occur over a very limited area anteriorly, and deep in the fissure of Rolando.

4. These latter bodies average 46 μ × 23 μ, but frequently attain to dimensions of 66 μ × 41 μ in the upper extremity of the convolution. The nucleus measures 13 μ in diameter. The largest cells observed in this region measured 88 μ × 41 μ.

5. The average size of the ganglionic cells is invariably greater than the largest elements of the third layer, which is by no means the case in convolutions posterior to this region.

6. These great cells diminish in size (as do those in the frontal regions) towards the lower extremity of the gyrus, as exhibited by the following table:—

	Average Size of Ganglion Cell.	Largest Cells.
Left Ascending Parietal (upper extremity) ..	$66\mu \times 41\mu$	$88\mu \times 41\mu$
Do. (middle third) ..	$46\mu \times 37\mu$	$55\mu \times 32\mu$
Do. (lower third) ..	$41\mu \times 24\mu$	

Spindle Layer.—The elements constituting this formation do not differ from those of the frontal regions. Their distribution is precisely similar, as they attain their greatest depth beneath the summit of the gyrus, and lie parallel with the surface of the cortex in the dip of the sulcus.

NOTE.—In this imperfect sketch of the histology of the cortex of the motor area I have been compelled to omit reference to the structure of postero-parietal and paracentral (Betz) lobule. The latter, which is of especial interest, is a small lobule on the inner aspect of the hemisphere immediately in front of the fissure of Rolando, limited below by the Gyrus Fornicatus. I quite endorse the observations of Betz with regard to this lobule, the posterior two-thirds exhibiting in its fourth layer a dense grouping of large ganglionic cells, which in size rival those found in the ascending frontal. It is stated by Prof. Ferrier,[1] that electrical excitation of the marginal convolution in the parieto-frontal region of the monkey occasioned movements of the head and limbs, apparently similar to those obtained by stimulation of the corresponding regions on the external surface.

Lamination of the Motor Area in the Cat.

(PLATE 2.)

Sections taken through the hemispheres of a cat, in an antero-posterior direction along the vertex, demonstrate the presence of a lamination identical in most respects with what has above been described as typical of the motor area in man. This arrangement, which I have stated to be distinctly five-laminated, and characterised by a remarkable series of ganglionic cells, is seen also in the cat to be restricted within

[1] Op. cit., p. 145.

Bevan Lewis

Cortical Lamination of Motor Area in the Cat

certain definite limits, and exhibits features most highly characteristic of this formation in the convolutions bordering upon the crucial sulcus. With the object of contrasting the individual elements of this region with those of man, I shall give a brief description of each layer of the cortex: after which, I propose to summarise the points of identity and dissimilarity apparent.

First Layer.—The cells of this layer, as in man, are of two forms. The smaller measure 5 μ in diameter, and contain a large spheroidal nucleus; the larger, which measure 9 μ, are frequently oval or pyriform, and exhibit a decided tendency to assume the form characteristic of those bodies known as Deiter's corpuscles, throwing off numerous prolongations which entwine upon the sheaths of the blood-vessels, and form connections with the under-surface of pia mater (Plate 2). As will be shown when describing the cortex of the sheep, a similar condition of these elements is present, but in a still more marked degree. The depth of this layer averages ·34 of a millimeter, being one-seventh to one-eighth the full depth of the cortex. If this is contrasted with the same layer in man, a marked distinction is observed—thus: although in frontal gyri the *absolute* depth of the first layer in man may vary from ·25 to ·34 of a millimeter, yet its *relative* depth to the whole thickness of the cortex is not above one-fifteenth or one-sixteenth. (*Vide* Table.)

Second Layer.—Small irregular pyramidal or ovoid cells containing a comparatively large spheroidal or occasionally oval nucleus constitute this formation. The cells measure 10 μ × 6 μ, the nucleus 5 μ in diameter—a measurement slightly below that of the corresponding elements in the sheep (*vide* Table of Measurements). The apex process of these cells is directed radially to the surface of the cortex, and a few extremely delicate branches arise from the basal angles. They are decidedly more irregular and stunted than in man, and a bifid condition of the apex process is frequent either close to the body or at a short distance above it, reminding one of the mode in which the apex process of a Purkinje cell of the cerebellum is given off. The distinct limits of this layer, dependent for its recognition on the small size and close

approximation of elements, is quite as marked as in the human brain. We find amongst these smaller cells larger bodies in scanty quantity, measuring 13 μ × 10 μ, with a nucleus of 9 μ diameter; these cells closely resemble those of the subjacent layer. Other bodies are also found here, measuring 9 μ × 4 μ, and with nuclei which average 4 μ, staining *very feebly* with aniline black, thus differing from the nerve-cells whose nuclei stain of a deep black by this reagent. These elements are connective and correspond to the larger elements referred to in the first cortical layer.

Third Layer.—The average size of the nerve-cells is 16 μ × 9 μ; that of the nucleus 8 μ. This is again below the dimensions attained in the corresponding region by the nerve-cells of the sheep. The largest cells, however, measure 23 μ × 13 μ and the nucleus 9 μ. Their protoplasm is extremely delicate, and numerous secondary processes as well as an apex and basal process are given off by the cell. As in man, the characteristic elements of this layer are accompanied by *small pyramidal cells* which extend through the whole depth of this formation, and at certain points aggregate into a well-defined stratum above the ganglionic series. Perivascular and connective cells are also found in this layer.

Ganglionic Layer.—The prominent features of this stratum enable us to identify it with the fourth layer of the motor area in man. A pale band containing large multipolar cells—the largest in the whole brain—succeeds directly to the large pyramidal cells of the third layer, interspersed amongst which are smaller cells of the same general characters.

I. *Form.*—The oval, or pyriform, is most general, the pyramidal is less frequent, and the fusiform is still more rarely found. The bodies of these cells are plump, contrasting in a marked degree with the compressed, elongated, and irregular bodies of these cells in the sheep. This fact may be also verified by consulting the table of measurements, where the relative breadth of these cells is far greater in the cat than in the sheep. The nucleus is invariably spheroidal, except in the fusiform cell, where it becomes oval in contour.

II. *Size.*—These ganglionic cells are smallest in the anterior limb of the sigmoid gyrus, where they average 39 μ × 17 μ,

the smallest not exceeding 26 μ × 14 μ. In the posterior limb of this gyrus, however, I obtain an average of 46 μ × 17 μ, a very large number even rising to 69 μ × 27 μ. It is at the junction of these two limbs, *i.e.* the bend of the sigmoid gyrus round the extreme lateral end of the crucial sulcus, that we find the greatest cells. In this position an average of a large number of measurements gave 83 μ × 37 μ, whilst occasionally a cell was met with assuming the gigantic proportions of 106 μ × 32 μ, with a nucleus 13 μ in diameter. It will be allowed then that in point of size these elements bear no mean comparison to those of the corresponding layer in the human brain.

III. *Processes.*—The number of processes, including apex and basal process, was estimated from a large series of vertical sections of the cortex, and the average obtained was slightly over eight, but in several large cells as many as thirteen were observed. The secondary branches, as in man, radiate outwards and downwards in all directions, the cell being the centre of their area of distribution.

IV. *Distribution.*—It will be remembered that we referred to the peculiar arrangement in clusters which Betz had observed in these cells in the human cortex. These "nests" of two, three, or more cells, occasionally as many as seven, are characteristic of this region in the cat. In the upper third of the sigmoid gyrus these clusters are uniformly spread through anterior and posterior limbs of the gyrus.[1] In the middle third they chiefly occupy the summit and anterior aspect of the posterior limb where it dips into the crucial sulcus, and through the anterior limb of this gyrus they are found but scantily scattered. Still lower they appear strictly limited to that portion of the gyrus which forms the walls of the sulcus (*cruciatus*), where the clusters are not only dense and closely aggregated but the cells are of large size. The lowest portion of the sigmoid gyrus which curves round the extreme end of the sulcus exhibits large and dense clusters of these ganglionic cells, covering the region which is figured in Ferrier's drawings as No. 4 and 5. Here these cells attain to the dimensions of 83 μ × 37 μ.

[1] The pre-frontal and post-frontal gyri of some authors are here indicated by anterior and posterior limbs respectively.

Structure of the Cortex Cerebri in the Sheep.

(Plate 3.)

Lamination.—As in the cat, we find a five-laminated formation peculiar to a limited region, to which region I wish more particularly to invite attention. Its structure presents features which I believe warrant us in assuming that the region examined is from every point of view the analogue of those which are regarded as motor in the cat and higher mammalia.

First Layer.—The larger and smaller cells of this layer measure respectively 9 μ and 5 μ in diameter, their conformation and reactions being in every way similar to those of the cat. The neuroglia, composed as it is of connective and nervous elements, is from a preponderance of the former tissue peculiarly firm and coarse. Immediately subjacent to the pia mater a large number of bodies resembling Deiter's cells are usually seen, their processes interlacing in a most intricate plexiform arrangement, and giving rise to such firm attachment of the cortex to the pia mater that it is scarcely possible to separate this membrane from certain portions of the cerebrum without tearing the cortex. They are found abundantly along the course of the blood-vessels, and have been stated to be seen in the corresponding layer in the cat. Dr. Major has noticed the corpuscles as of rare occurrence, also, in the first layer of the brain of the Chacma Baboon.[1] The depth of this layer averages ·55 of a millimeter, and a glance at the drawings representing a section of the cortex in the cat and sheep (Plates 2 and 3) will at once render evident the great difference in the relative and absolute thickness of this layer.

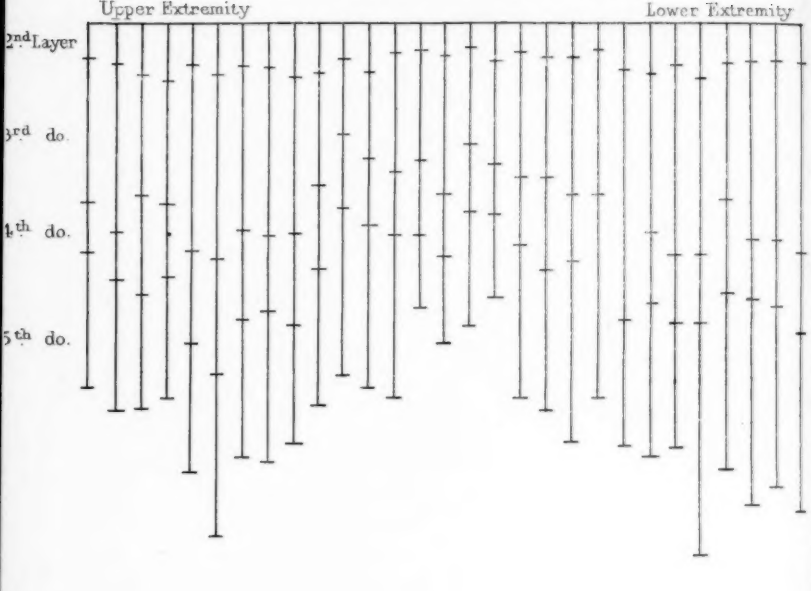
Second Layer.—This layer in the sheep is a very narrow band of nerve cells, extremely irregular in contour, being small, oval, fusiform, pyramidal or angular bodies, stained very feebly by aniline, but containing a large spheroidal nucleus, which assumes a deep black hue with that reagent. The apex process is directed radially to the surface of the cortex, but very frequently assumes an irregular course. The cell itself may be bifurcate at the apex, or that process may divide into

[1] 'Observations on the Brain of the Chacma Baboon.' *Journ. of Mental Science*, Jan. 1876.

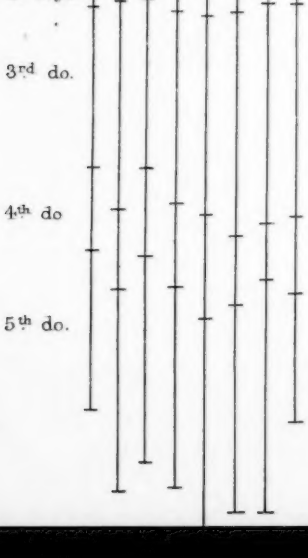
Plate 3

Cortical Lamination of the Motor Area in the Sheep. Bevan Lew

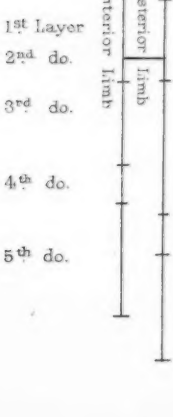
LEFT ASCENDING PARIETAL (HUMAN)



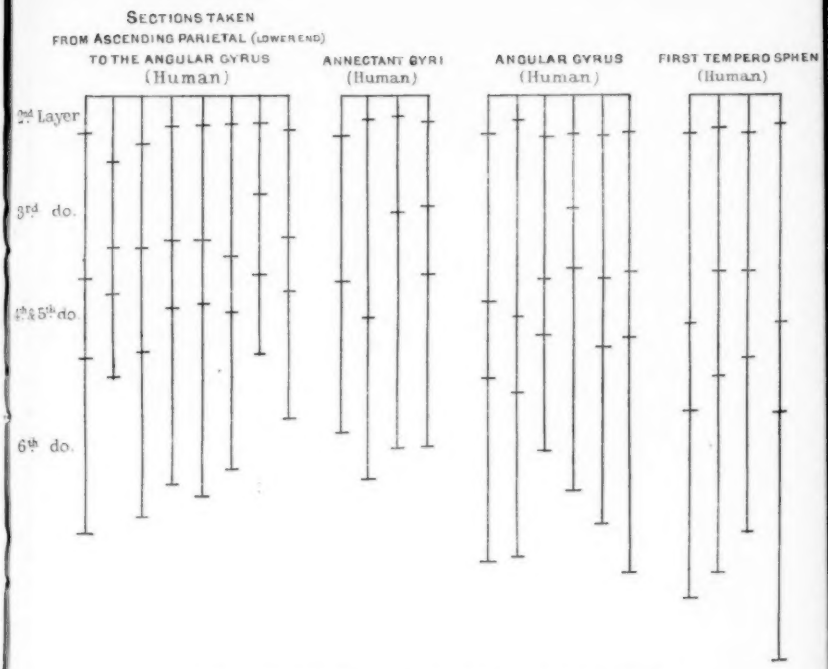
SECOND FRONTAL GYRUS
(Human)

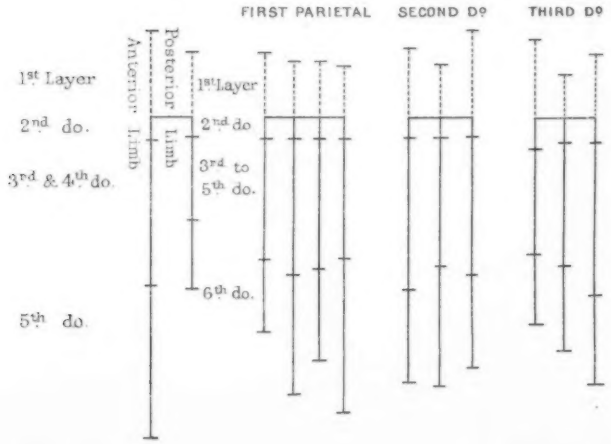


SIGMOID GYRUS OF CAT.



COMPARATIVE DEPT TH
IN THE CORTEX OF MAN
Drawn to scale





EP THE LAYERS
MAT AND THE SHEEP.

two spreading arms just beyond its origin from the cell. In this layer we also find larger cells, which resemble in general characters those of the upper regions of the third layer. The small elements measure 13 μ × 6 μ, and their nucleus 6 μ. They have on an average five branches.

Third Layer.—The nerve cells are very irregular in outline, but the majority assume the pyramidal form. They are frequently bifurcate, the two branches at the apex diverging widely so as to give the cell a peculiar horned appearance. The contorted form assumed by this irregular course of the apex process accounts for the frequency with which this process is cut off short in hardened preparations. In vertical sections we generally find eight branches present, inclusive of apex and basal process. The average measurement of these cells was 18 μ × 10 μ; that of their nucleus 6 μ in diameter. This layer is much shallower in the posterior than in the anterior limb of the sigmoid gyrus.

Ganglionic Layer.—The cells of this formation, which in the sheep present some very remarkable features, will be considered under the heads of form, size, processes and distribution.

I. *Form.*—These elements are extremely irregular in form, and very rarely assume the plump, rounded, or oval contour seen so frequently in man, the monkey, dog, and cat. The average dimensions given for these cells below (46 μ × 11 μ) will suffice to show how peculiarly elongated and narrow they are in some regions. In these fusiform cells the nuclei are invariably oval. In other regions, however, especially the posterior limb of the sigmoid gyrus, these cells are larger and more of the pyramidal or oval outline.

II. *Size.*—At the upper ends of the sigmoid gyrus the average dimension of these cells is 36 μ × 17 μ for the posterior, and 46 μ × 11 μ for the anterior limb of the gyrus. In the former position we not unusually find numerous cells measuring 46 μ × 23 μ, approaching in outline and size those seen in the cat, whilst the largest observed measured 65 μ × 23 μ. The nucleus in the elongated cell is oval, and measures 9 μ × 4 μ; in the broader and larger cells it becomes spheroidal and 9 μ diameter.

III. *Processes.*—Of a large series of these ganglion cells the

average number was slightly under eight, as seen in vertical sections: the largest number observed was twelve. This enumeration includes apex and basal process. The apex process is often peculiarly contorted and bifurcate, as in the cells of the third layer; nor does it display the rapid and delicate attenuation presented by these processes in the human brain. Its distinctness on the other hand is so marked that I have frequently traced it in the sheep, through the third and second up to the first layer, giving off few or no branches until it has entered the first layer, where it can be seen dividing and subdividing into several delicate processes.

IV. *Distribution.*—The position, size, and mode of distribution of these cells indicate their identity with those of the fourth layer in the motor area of man. They are arranged in clusters, answering to the nests of Betz, but these clusters embrace a far larger number of cells than are found in the corresponding cell clusters in man or the cat. In the posterior limb of the sigmoid gyrus we find these clusters furthest apart, their distance ranging from 140 μ to 110 μ; but in the sulcus (*cruciatus*) they are more crowded, whilst in the anterior limb of this gyrus they are separated by intervals of scarcely more than 90 μ. Again, the constitution of these clusters differs widely in these two districts. Thus, in the posterior limb of the convolution, the cells are not only of smaller size but are disposed in groups of two, three, or at most, five cells, but becoming more numerous towards the crucial sulcus. In the anterior limb of the gyrus, the groups assume a peculiar and characteristic arrangement, each cluster occupying oblong areas, measuring 460 μ in depth, by 110 μ in width, and include a very great number of cells of large size, frequently as many as twenty being seen in vertical sections. These cells are closely packed within the clusters, at a distance of from 6 μ to 9 μ apart, and are peculiarly compressed and elongated in contour. The position of these clusters may be understood by supposing the sigmoid gyrus to be divided into an upper, middle, and lower third. It will then be found in the upper segment that scarcely any of these cells appear in the posterior limb, but they are present in dense clusters in that portion of the anterior limb

which forms the wall of the crucial sulcus, spreading over its summit to its anterior aspect. In the middle third a smaller grouping of these clusters is detected in the posterior segment of the convolution; but no dense clusters are met with except at the anterior aspect of the front limb of the gyrus, where just beyond its summit there is an extraordinary development of these cells.

In the lower third of this convolution, where it bends round the lateral extremity of the crucial sulcus, a very extensive grouping of these cell clusters covers the whole anterior aspect of the gyrus thickest in front, and gradually thinning off posteriorly, so that few are seen beyond the summit.

NOTE.—I have omitted a detailed description of the spindle layer in both the cat and the sheep, as the individual elements resemble in form those found in the human brain. The depth of this layer beneath the summit of the convolution is figured in the accompanying Table, where it can be readily contrasted with the corresponding formation in man.

TABLE OF MEASUREMENTS.

	MAN.		CAT.	SHEEP.
	Ascending Frontal.	*Ascending Parietal.*	*Sigmoid Gyrus.*	*Sigmoid Gyrus.*
First Layer—				
Small Cells . .	$6\mu - 9\mu$	$6\mu - 9\mu$	5μ	5μ
Large Cells . .	13μ	$13\mu \times 6\mu$	9μ	9μ
Second Layer . .	$11\mu \times 6\mu$	$8\mu \times 6\mu$	$10\mu \times 6\mu$	$13\mu \times 6\mu$
Third Layer—				
Upper Series .	$12\mu \times 8\mu$	$15\mu \times 11\mu$	$16\mu \times 9\mu$	
Lower Series .	$41\mu \times 23\mu$	$32\mu \times 18\mu$	$23\mu \times 13\mu$	$18\mu \times 10\mu$
		(Largest $51\mu \times 32\mu$)		
Fourth Layer—			*Ant. Limb.* $26\mu \times 14\mu$ to $39\mu \times 17\mu$	$46\mu \times 11\mu$
Ganglionic Cells	$71\mu \times 35\mu$[1]	$37\mu \times 21\mu$	*Post. Limb* $46\mu \times 17\mu$ to $69\mu \times 27\mu$	$36\mu \times 17\mu$
			Bend of Gyrus $83\mu \times 37\mu$	$46\mu \times 23\mu$
Largest observed	$126\mu \times 55\mu$	$88\mu \times 41\mu$	$106\mu \times 32\mu$	$65\mu \times 23\mu$

[1] Dimensions given by Betz = $10\mu - 120\mu$ by $50\mu - 60\mu$.

Measurements of the Cells of the Ganglionic Layer, at various points of the Human Cortex Cerebri.

	Ascending Frontal.	*Ascending Parietal.*
Upper Extremity of Gyrus .	$60\mu \times 25\mu$. Largest $90\mu \times 45\mu$	$37\mu \times 21\mu$. Largest $88\mu \times 41\mu$
Opposite First Frontal. . .	$45\mu \times 20\mu$. Largest $69\mu \times 27\mu$	Largest $46\mu \times 47\mu$
Lower Extremity	$35\mu \times 17\mu$. Largest $41\mu \times 18\mu$	$24\mu \times 13\mu$. Largest $41\mu \times 25\mu$
	First Tempero-Sphenoidal.	*Angular Gyrus.*
Lower Extremity of Gyrus .	$23\mu \times 11\mu$	$22\mu \times 11\mu$ to $23\mu \times 13\mu$.
Upper Extremity of Gyrus .	$25\mu \times 14\mu$	

Note.—In the above measurements the long and short diameter of the cell, and, except where otherwise stated, the *average* dimensions, are presented. The convenience of expression of the *micromillimeter* by the sign μ, and its very general adoption by histologists, have induced me to employ it in preference to the decimal form of expression.

ON SKULL MAPPING.

BY CROCHLEY CLAPHAM, L.R.C.P. LOND., F.S.S.,

Member of the Anthropological Institute of Great Britain and Ireland.

PRESUMING that the internal configuration of the skull is a matter worth consideration, the following notes and diagrams may be found not altogether devoid of interest.

On reference to the Plate it will be seen that I have delineated the skull-line in two directions corresponding respectively to the circumferential line of the horizontal and perpendicular planes at the level of their greatest areas.

The method employed to obtain these lines is one requiring considerable care in the necessary manipulations, but beyond this presents no difficulties.

It is as follows: The calvarium having been removed in the ordinary way—care being taken that it is cut at a level of about an inch above the superciliary ridges in front and the occipital protuberance behind, and that the line is as straight as possible,[1]—the brain and membranes are cleared away, and a strip of lead 17 inches long, three-quarters of an inch wide, and of the thickness of half-a-crown, is laid upon the basis cranii in the direction of its length. The anterior end of the lead must be slit for about 3 inches, so as to enclose the crista galli, and the two strips brought up to the cut margin of the skull anteriorly. The whole length of the lead included in the skull is now to be pressed close down on to the bone, and pushed into all the hollows, bent over the posterior clinoid process and into the

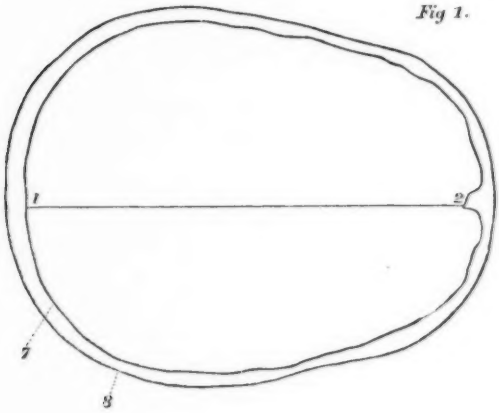
[1] This is best insured by the employment of an iron skull-holder, such as is used in the Post-mortem Room at St. Thomas's Hospital.

foramen magnum, then up the occipital bone to the cut margin posteriorly.

The spare lead is to be bent over forward, and its extremity placed against the tips of the anterior portion, so as to prevent springing.

The position of the torcular Herophili having been marked on

Fig 1.



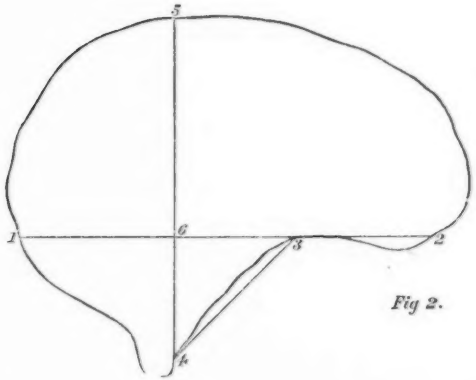


Fig 2.

the lead with chalk, the strip may be removed bodily, placed on a sheet of paper, and the part which has been in apposition with the skull drawn round with pencil.

A perfect copy of the basis cranii in its median line will be thus obtained; and the same process being carried out with the calvarium, and adapted to the line already drawn, the complete internal antero-posterior circumference will be shown (Fig. II.).

To get the horizontal circumferential line, a ring of bone, a quarter or third of an inch thick, is carefully sawn off just below the line of incision made in removing the calvarium. If properly cut, the ring will lie flat on the table, and should be cleaned and preserved.

By placing this ring on paper, and drawing closely round it on both sides, the internal and external circumferential lines of the skull are obtained, as shown (Fig, I., 7, 8).

The lines thus taken in the two directions should be figured on the same piece of paper for purposes of comparison.

A straight line is now drawn on the perpendicular section (Fig. II., 1, 2) from the point corresponding with the torcular Herophili to the frontal bone, and just touching the posterior clinoid process (Fig. II., 3).

From 1 to 2 will constitute the base line of the skull.

If a line be now drawn at right angles to this base line, and with its lower extremity touching the anterior margin of the foramen magnum (Fig. II., 4), its upper end (Fig. II., 5) will be found to correspond, almost absolutely, with the highest point of the antero-posterior arch of the skull, and to cut the horizontal circumferential line at its point of greatest width. This line (Fig. II., 4 to 5), will be spoken of as the *line of intelligence*, and the point at which it cuts the base line (1 to 2) determines the relative size of the anterior and posterior portions of the brain, and bears, I have reason to believe, a relation to the degree of intelligence of the individual.

The space below the base line is occupied by the cerebellar and ganglionic portions of the brain.

Taking the posterior clinoid process as a fixed point, the line joining it with the anterior margin of the foramen magnum, and which corresponds pretty nearly with the basilar process of the occipital bone, will be *more* or *less* inclined as the *line of intelligence* is moved backwards or forwards. In other words, the angle 4 3 2, Fig. II., will be larger or smaller.

I may premise that this angle is remarkably open in some

of the lower forms of idiocy, almost indeed approaching the ourang-outang where it is 139°. The average of 20 insane males gave 129°, and of 12 insane females, 130° for this angle.

The only skull of a sane person which I have examined on this point gave 120°, but whether the sane average is as small as this I am unable at present to say.

Of course the above plan of delineating the interior of the skull is only applicable *post mortem*, but with the exception of the posterior clinoid process all the points used may be determined during life; and should it ever be possible to fix the position of the clinoid in the living state, I will undertake to draw a practically accurate diagram of the basis cranii and vault, as shown in the Plate, from external inspection alone.

I submit the present paper in the hope of inducing asylum medical officers and others having like opportunities, to keep diagrams of the internal skull-figure in all cases on which post-mortems are made.

I shall have some further remarks to make in a future paper on the results of my own observations upon a number of insane crania examined after the above method.

Critical Digests and Notices of Books.

Duret on Cerebral Traumatism. H. DURET. 'Etudes Expérimentales sur les Traumatismes Cérébraux,' Thèse pour le Doctorat en Médecine. 4to, pp. 337. 19 Plates and Chromolithographs. Versailles, 1878.

M. DURET, already well-known by his researches in cerebral physiology, has in this elaborate work, full of careful and laborious experiments, thrown quite a flood of light on many obscure points in cerebral pathology, and placed on a firm basis of fact much that has hitherto rested on mere speculation.

This is the first part of a work which M. Duret intends to carry out into its practical application, and deals with the mechanism and effects of cerebro-spinal shock, the effects of increase in the intracranial pressure; and the special rôle of the nerves of the dura mater, of the meningeal vessels, and of the several encephalic centres in traumatic lesions of the brain.

The main points which our author establishes in regard to the mechanism of shock are, that the cranium is a cavity with elastic walls, and filled with contents which are practically incompressible. Hence a sudden impact at any part of the cranial wall is transmitted to all parts of the interior, mainly through the cerebro-spinal fluid. At the point of impact a circle, or *cône de dépression*, is formed, to which there corresponds a *cône de soulèvement*, chiefly in the line of the thrust, and hence, if resistance is met with, the phenomenon of what is usually termed *contrecoup*, occurs, and not, as is commonly supposed, by actual concussion of the cerebral mass against the cranium.

If, however, the line of thrust coincides, more or less, with

the ventricular axis, the effect is felt chiefly at the base, more particularly in the fourth ventricle and restiform tracts, where lacerations and hæmorrhages result; or even down the whole spinal canal.

The lesions produced almost exclusively occupy the regions where the cerebro-spinal fluid circulates. These lesions are of various degrees, interstitial or superficial, and are carefully described, and beautifully figured in the chromo-lithographic illustrations which accompany the work.

The physiological effects are various, and experimental evidence is given in support of the following statements:—

At the moment of impact, an excess of tension occurs in the lymphatic sheaths which surround the cerebral blood-vessels, and, in consequence, there is a momentary anæmia throughout the whole encephalic vascular system.

This anæmia is augmented and maintained by reflex vascular constriction, of which the starting-point is irritation of the restiform tracts, and the sensory parts of the mesencephale.

To this general vascular constriction there succeeds an equally extensive vascular dilatation, which, by interfering with nutritive interchange, paralyses the nerve centres. Occasionally the vaso-motor paralysis continues until inflammatory reaction sets in, and the nervous disorders continue till death, if this is the end of the scene.

In a clinical point of view the symptoms of cerebral shock are to be differentiated into bulbar and medullary.

Their intensity and duration vary with the violence of the shock, and the point at which the primary impact occurs.

In *slight* shock the phenomena are transitory, lasting only a few moments. In *grave* shock the duration may be from several minutes to several hours. The phenomena in each case may be divided into two periods.

The first period comprises two phases: (*a*) the spasmodic or tetanic phase; (*b*) the paralytic phase.

(*a.*) Spasmodic or tetanic phase. This is characterised by vascular constriction, and general anæmia of the nerve centres. The *cerebral* functions are suddenly annihilated, there is loss of intelligence, voluntary motion, and sensory perception.

The *bulbar* functions suffer more or less. There is always cardiac and respiratory syncope, more or less prolonged, and a tetanic state caused by irritation of the sensory tracts of the mesencephale, and particularly of the restiform tracts. This is an *exaltation* by mechanical or traumatic irritation of the reflecto-motor fibres. At this period the internal temperature rises, the pulse is bounding, the heart contracts with force, and the respiration, suspended for an instant, becomes laborious, in consequence of the spasm of the respiratory muscles. This phase does not last more than a few seconds, or minutes at the outside.

(*b.*) Paralytic phase. According to the degree, the *cerebral* disorders are somnolence, sopor, coma, loss of voluntary motion, and sensation, more or less marked.

The *bulbar* symptoms are, secondary acceleration of the respiration; on which, if the lesion is grave, there follows a retardation, often of a very marked character. The pulse is slow, but not full, for the heart contracts softly, and owing to the general vascular dilatation there is scarcely any resistance. The internal temperature is lowered; for the blood, which at the moment of spasm accumulated in the viscera, now returns towards the periphery. The *medullary* symptoms are complete muscular prostration, loss of muscular and vascular tone throughout the whole body.

Second Period.—This is the period of congestive and inflammatory reaction. Most frequently it is dependent on the presence of localised or diffuse lesions, such as hæmorrhagic foci, rupture of the vessels or of the nerve tissue, rupture of the capillaries in the lymphatic granules of Robin, punctiform hæmorrhages scattered throughout the nerve centres. The coma continues for the reasons indicated, or is succeeded by somnolence or sopor; sensation is obtuse, and movement is automatic, or carried out only under the influence of powerful stimulation. The bulbar symptoms consist in febrile pulse and respiration, and elevation of the temperature. The medullary functions are often exalted.

In shock *foudroyant*, death results from sudden anæmia of the bulb, either in consequence of sudden rise in the internal pressure of the cerebro-spinal fluid, or in consequence of the

violent reflex vascular contraction. In this case, the cardiac and respiratory syncope, which are transitory in the slighter forms, prove fatal.

The point of application of the violence greatly influences the phenomena which ensue. In *frontal* concussion the effect is chiefly basilar, in the pons and bulb, and occasionally in the medulla. In *lateral* concussion the reaction is chiefly in the opposite cerebral hemisphere, and in this particular case, the symptomatology warrants a special name—*choc hémisphérique*. Though there is always an effect on the bulb, which explains the momentary arrest of the cerebral circulation and cerebro-bulbar symptoms, it is not uncommon to observe unilateral disorders, such as unilateral spasm, propulsion or movement *de manége*. Later on, if grave lesions exist, hemiplegia or hemianæsthesia may occur, on the same side as the violence, owing to the lesions occurring by *contre-coup* in the opposite hemisphere. When the concussion is *occipital*, the influence is felt in the frontal lobes, in the posterior parts of the hemispheres, and in the bulb at the same time.

In concussions of the *nuque* the bulb may be affected by return cerebro-spinal flux. Each variety of concussion may cause special lesions corresponding to the region to which violence is applied.

When localised lesions exist, their symptoms are manifested by localised affections, which can be distinguished from the general phenomena of concussion. These affections consist in exaltation or paralysis of function, in accordance with the kind of lesion. Lesions of the cortical motor centres, of the peduncular expansion, of the bulb or medulla, indicate their presence by localised spasms (*secousses*) or paralysis, in the muscles presided over by the centres which are injured. In the case of cortical lesions, the spasms may become generalised under the form of epileptic attacks, but they always commence with the centre chiefly affected by lesion.

Lesions of the sensory parts, such as of the nerves of the dura mater, posterior part of the internal capsule and of the cerebral peduncle, restiform bodies, sensory nerves and posterior columns of the bulb and medulla, manifest themselves in

hyperæsthesia, anæsthesia, and in reflex motor and vaso-motor spasms.

The phenomena of *apoplectic* shock and shock of concussion are essentially similar in causation. As regards *embolic* shock the causation is different, as there is here no sudden access of pressure, causing displacement of the cerebro-spinal fluid, and thereby affection of the bulb and restiform tracts. In consequence of the sudden closure of a vessel by an embolus, there is a temporary vacuum at the part, which causes an afflux of blood and cerebro-spinal fluid from the other regions of the encephalon. Hence there is a sudden *decompression* of the blood-vessels, the result of which is rupture of capillaries, or momentary loss of function of the various encephalic centres.

In the second chapter M. Duret, besides giving an analysis of former researches on the mechanism of Cerebral Compression, describes numerous experiments, in which he produced compression either by injection of measured quantities of liquid between the dura mater and cranium, or into the arachnoid space; or by the injection of coagulable liquid, the volume of which could be measured, or by pressure on the surface of the brain with cushions of wadding, sponge, &c.

These various experiments lead M. Duret to very definite conclusions respecting the mechanism and symptomatology of cerebral compression, of which the following is a résumé.

A foreign body introduced within the cranial cavity acts not only locally on the subjacent parts, but also, if the diminution of the cranial cavity is sufficient, on the nerve centres generally. There are, therefore, two orders of symptoms, viz. local and myelencephalic, or cerebro-bulbo-medullary.

(1.) *General Symptoms.*—The physical conditions requisite for its production, are a certain increase in the intra-cranial pressure, or a sufficient diminution of the intra-cranial space. As to the amount of pressure necessary, M. Duret arrives at conclusions similar to those of Pagenstecher. It varies from 8 to 15 cm. of mercury in the milder, to from 20 to 23 cm. in the gravest form. When the pressure exceeds the arterial tension, death occurs in a few minutes.

This, on the average, requires 20 to 25 cm. of mercury.

A reduction of the capacity of the intra-cranial cavity by 7 to 8 per cent., by injection between the dura mater and the cranium, in general causes manifest symptoms; but when the injection is made into the arachnoid space 8 to 9 per cent. diminution is necessary, and death does not result till a reduction of 18 per cent. has taken place. This is due to the fact that the wax moulds itself over the whole surface, instead of acting with concentrated force.

The pressure exercised at any one point of the hemisphere is transmitted by the cerebro-spinal fluid to the whole nerve centres, and in particular to the perivascular lymphatic sheaths. In consequence of this the circulation in the nerve centres is disturbed, and in direct proportion to the degree of pressure, or diminution of the cranial space.

1. With slight pressure, the intra-cerebral circulation is not markedly modified: the absorption of some of the cerebro-spinal fluid, the extensibility of the vertebral ligaments, and of the venous sinuses allows of room being made. There are no general nervous disturbances.

2. With medium pressure, the compressed vessels admit of less blood into the nerve centres, and there is therefore ischæmia more or less pronounced of these important parts. Hence result *cerebral* disturbances, viz. somnolence, fatigue, or muscular prostration, and obtusion or loss of sensibility; *bulbar* disturbances, viz. slow pulse, laboured respiration, and lowering of the temperature; and *medullary* disturbances, viz. diminution of reflex excitability, loss of vascular and muscular tone.

3. With a high degree of pressure, the circulation in the nerve centres is almost completely stopped. Hence ensue coma or sleep, from cerebral disorder; excessively slow pulse and laborious or stertorous respiration, with progressive and considerable fall of temperature, from affection of the bulb; and lastly, complete suppression of the medullary functions shown in abolition of reflex excitability, and of vascular and muscular tone.

4. When the pressure exceeds the arterial tension, there is absolute arrest of the circulation and death.

II. *Local Symptoms.*—These are the direct result of the com-

pression of the parts subjacent to the point where the pressure is excited. On the convexity of the hemispheres, the action may be limited to the grey matter or the medullary fibres, or may extend to the peduncular expansion, cerebral peduncles, or even to the bulb, according to the degree of pressure.

1. If the cortex only is affected, phenomena of exaltation or paralysis are observed, according to the degree of pressure. In particular, pressure on the motor area causes localised spasms or monoplegiæ.

2. If the whole hemisphere is compressed towards the base of the cranium, hemiplegia results, if the pressure is anterior; and hemianæsthesia, if the pressure is exerted posteriorly.

3. Lastly, if the compression flattens the bulb and the basilar artery, bulbar troubles become predominant. In this case death rapidly ensues if the pressure persists, by arrest of the heart and respiration.

The next chapter deals with the dura mater, and its relation to cerebral lesions. This we have given in full, with the exception of experimental details, at p. 29. The facts which M. Duret has there brought forward are of exceeding importance, and many of them I can corroborate from my own observations. Many of the deductions which M. Duret draws from these facts are, I think, fully justified; but I am inclined to think that he places on the reflecto-motor influence of sensory irritation more than it will legitimately bear. While irritation of the nerves of the dura mater affords a clear explanation of the well-known fact that convulsions frequently occur on the same side as cerebral lesion and paralysis on the opposite, and similar phenomena, it does not seem to me that reflex irritation affords a satisfactory explanation of the late rigidity in cases of hemiplegia. This rigidity is constantly confined to the most paralysed parts; and I have difficulty in conceiving how irritation of sensory regions sufficient to keep up a localised permanent contracture (a fact of itself of very unusual occurrence) could exist without also causing acute pain and other sensory disturbances, which are by no means necessarily met with in this condition. M. Duret now thinks with M. Pitres, that the tetanic pleurosthotonus which results from electrical irritation of the caudate nucleus is really due to conduction to,

and irritation of the sensory part of the internal capsule or of the restiform bodies. This I by no means admit; and would ask M. Duret and M. Pitres, if such were the case, why irritation of the optic thalamus, which is situated nearer these sensory regions, has no such effect.

I think M. Duret is inclined to be too exclusive, and does not take into account the fact that the same phenomenon need not always have the same mode of causation. Though reflex contracture is a very important form of contracture, it does not follow that contracture is always of reflex origin.

Two short chapters follow: the one on the rôle of the meningeal vessels in cerebral traumatism, and the other on the effects of lesions of special regions. Though these contain many interesting details, they have less of novelty than the preceding: and, as our analysis has already extended to such limits, we must take leave for the present of this highly-important and valuable memoir.

D. Ferrier.

Darwinism tested by Language. By Frederick Bateman, M.D. With a Preface by Edward Meyrick Goulburn, D.D., Dean of Norwich. 8vo. Rivingtons. London.

Science, under the patronage of the Church, by an author whose personal character surely did not need the testimonial of the Dean of Norwich Cathedral, who is good enough to publish his opinion that a Fellow of the Royal College of Physicians "*is a Christian in something more than in name!*" It is possible, however, the testimonia. is not altogether superfluous; for, if a stranger were to apply to Dr. Bateman's Christianity the test which he applies to Darwinism by taking this book for analysis on the question of "Christianity tested by Language," the result would, perhaps, be as adverse and as misleading. Here are a few fragments of language to test with:—"Yes, Mr. Darwin, looking back through the dim vistas of untold ages, traverses the corridors of time, and, plunging into a bygone eternity, from the dark recesses and chasms of which, lighted up only by the beams from his

own distorted imagination, he drags into existence this monster of his own creation—this ape-like Man."—p. 12.

Would it not have been more in accordance with Christian precept if the writer of this sentence in Cambyses' vein had thought of the beam which might possibly exist in his own eye, rather than of the beams in the distorted imagination of one whom other men speak of, whether they agree with him or not, with reverential regard? In reference to a paper the author himself quotes from Draper, which is infinitely less worthy of the rebuke, he remarks, "I need scarcely add that the cause of truth is not likely to be advanced by such rhetorical farrago, or rather, I should say, by such coarse and vulgar abuse." —p. 194. Again, the author says, "Mr. Darwin tackles this difficulty in the following specious terms."—p. 17. "And so, forsooth, it is upon evidence like this, that we are asked to forego the cherished traditions of our forefathers, and to substitute the audacious theories of yesterday."

All this about Darwin himself, whose disciples fare almost worse, for of them our author writes: "I must enter my protest against the extremely illiberal attitude assumed by some of the Evolutionist writers—an attitude which savours of sharp and clever diplomacy, rather than of fair and honourable discussion." "Their writings being stamped with the most fulsome eulogy of each other, and with gross abuse of their opponents, together with unseemly discourtesy towards all of those who venture to differ from them," &c.

We do not know what amount of vituperation is permissible in polemics, but the above, and similar language does seem rather strong for a Christian gentleman to use in a scientific argument. The sufficient explanation, however, would be that Dr. Bateman's book is polemical and not scientific.

The object of the author's publication may perhaps be given more succinctly in the words of his ecclesiastical introducer: "He aims at illustrating the truth in the grand old book that God made man in His own image; in the image of God created He him, and with this view he shows that [just as in the precinct of the Divine nature the Word, or Second Person, represents the Father to the creatures, so] the word as man's distinguishing characteristic represents him, is the great

medium whereby he throws into other minds the thoughts conveyed in his own."—*Preface.*

The author himself writes that, "Believing my published researches furnish a powerful and original argument against the doctrine of evolution," "I hope that I can furnish an additional and original argument against this dangerous heresy, by showing that the possession of articulate language establishes a difference between men and animals—a difference not of degree only, but of kind. In order to establish my position, I shall have to consider three propositions:—

"I. That Articulate Speech is a *distinctive* attribute of man, and that the ape and the lower animals do not possess a trace of it.

"II. That Articulate Speech is a universal attribute of man—that all races have a language, or the capacity of acquiring it.

"III. The Immateriality of the Faculty of Speech."

With regard to the first proposition, we may remark that if by articulate speech the author means speech composed of jointed sounds, or even merely distinct speech, there is certainly no native of Northumberland who can rival in its use a well-taught parrot.

But does articulate speech make a man? If so, what about educated deaf-mutes? What about that monkey of whom Locke writes in his chapter on Language? "For were there a monkey" [homme manqué], "or any other creature to be found, that had the use of reason, to such a degree, as to be able to understand general signs, and to deduce consequences about general ideas, he would no doubt be subject to law, and in that sense, *be a man*, how much soever he differed in shape from others of that name."

On the second proposition we may remark that the "capacity of acquiring" is sometimes very different from the possession of articulate language. The third proposition, however, leaves us so agape and aghast with surprise, that it is not until we have read on almost to the end that we have been able to discover anything like a possible answer to the conundrum. The author, abominating heresy, declares that an "antagonism to religion is patent in the writings of many

of the evolutionist school, who ransack the storehouse of natural science for weapons against Holy Writ. They unfurl the flag and blow the trumpet of defiance; their motto being *Ecclesia delenda est.*" Now one of the blazing heresies against the orthodoxy of the Church which the author thinks he is so strenuously propping is supposed to be materialism, and to be a materialist would to some venerable deans be worse than to be "a Christian merely in name." The orthodoxy, however, of Dr. Bateman is that "In later times the brain has been universally considered to be the organ of thought and intelligence," and that "this very indefinite and unnecessary word *materialism* is used as a kind of psychological scarecrow to frighten all those who are endeavouring to trace the connection between matter and mind." But, in addition to these fundamental views he is actually a disciple of the great Gall himself, of whose great work on the "Functions of the Brain," he says that "I look upon it as an imperishable monument to the genius and industry of one of the greatest philosophers of the present age."

In this difficult position, therefore, it is no great wonder that our author should be led to discover for himself a new element of Immateriality, if one may speak of elements in such connection, and behold it in articulate speech; so that *Vox et præterea nihil* has henceforth to be inverted in sense, seeing that it is just *vox* which is *nihil*, the sense of which is as undiscoverable as the source of the *nihil*. "Does the loss of it, immaterial articulate speech," asks our author, "necessarily imply organic lesions of structure—*material damages?* If it were so, how can we account for the cases recorded in which the restoration of the power of speech was due to the effect of a severe mental shock? We are all familiar with the story in Herodotus of the son of Crœsus, who had never been known to speak, but who at the siege of Sardis, being overcome with astonishment and terror at seeing the king his father in danger of being killed by a Persian soldier, exclaimed aloud, "Ανθρωπε, μὴ κτείνε Κροῖσον ('O man! do not kill Crœsus'). This was the first time he had ever articulated, but he retained the faculty of speech from this even as long as he lived." Our author gives full credence to Herodotus, and supports it by

other similar cases, one observed by himself; but in this case he fails to notice the all-essential distinction that the man who suddenly spoke had previously suddenly become speechless, and therefore had not found his voice for the first time. Guggenbühl recorded a really similar instance, in which one of his speechless cretins suddenly cried out, "Die Sönne, die Sönne," and always continued to speak afterwards. Unfortunately for the Swiss philanthropist a wicked and perverse generation did not believe him, the marvel only leading men to enquire as to his trustworthiness in other matters; and the result being that in no long time the sun set upon the cretin school of the Abendburg for ever. But the final proofs of the Immateriality of Speech and Broca's discomfiture are derived from the case recorded by Velpeau, in which a man in excellent health with the exception of prostatic disorder, "very lively, cheerful and full of repartee, and evidently in the possession of all his faculties, one remarkable symptom being his intolerable loquacity, died suddenly, and a careful autopsy was made. On opening the cranium *a cancerous tumour was found which had taken the place of the two anterior lobes!*" On this record our author remarks, "Here then was a man who, up to the time of his death, presented no symptoms whatever of cerebral disease; who far from having any lesion of the faculty of speech, was *unusually loquacious;* and who, for a long period prior to his decease, must have had *a most grave disease of the brain, which had destroyed a great part of the anterior lobes.*"

Please, however, to remark the difference between the two sentences which we have put in italics. And these are the kinds of facts which are expected to confute Broca and Ferrier; this is the kind of argument which, under the ægis of the Dean of Norwich, is hurled against Darwin. Verily, "the missing link" himself, that "unusually wise ape-like animal" against whom Dr. Bateman manifests such withering hate and scorn, could not have been expected to use worse arguments, if he argued at all, which, perhaps, he did not, being in several respects, perhaps, more rational in his mode of life than some of his human descendants. It is quite certain, for instance, that, unlike the miserable man whose suicide is recorded by

Dr. Bateman, he did not destroy himself in disgust at his ape-like ancestry.

But it might be that this lunatic had read the 119th Lyric of 'In Memoriam,' in which the Poet Laureate expresses his thought that "we are not wholly brain":—

> "Not only cunning casts in clay:
> Let Science prove we are, and then
> What matters Science unto men,
> At least to me? *I would not stay.*
>
> "Let him, the wiser man who springs
> Hereafter, up from childhood shape
> His actions *like the greater ape*,
> But I was born to other things."

Is it possible the self-destroyer, whose crime our author records, had carried into action the wild suggestion he had read in these lines?

To us it would seem a curious kind of religion which should lead a man, in stomachful pride, to fierce rebellion against the manner in which God has created us, whether His method has been that of evolution, or some other more speedy, but less intellectual one. If God is an intelligence, the great probability is that He has created man according to an intelligent method, and the only truly intelligent method which has ever been suggested is that for the probability of which Darwin has collected an amount of evidence which must be quite immeasurable, inconceivable, and incomprehensible to any mind capable of compounding the incongruous *bolus* of theology, metaphysics and science which is presented to us in this book.

JOHN CHARLES BUCKNILL.

Clinical Cases.

CASE OF CEREBRAL TUMOUR—SYMPTOMS SIMULATING HYSTERIA.

BY A. HUGHES BENNETT, M.D.,

Physician to the Hospital for Epilepsy and Paralysis, Regent's Park.

THE following case is worthy of record, not only on account of many intrinsically-interesting features connected with it, but also because during life the true nature of the disease was not ascertained. It serves to point out the difficulty of diagnosis in obscure nervous lesions, and the extreme caution that the physician should exercise in treating as a functional or emotional complaint what in reality may be serious and fatal organic disease. Such errors, more especially if no care or precaution in investigation has been neglected, often teach a useful lesson.

Miss A., a young lady aged sixteen, first consulted me on April 1st, 1876, complaining chiefly of blindness, imperfect hearing, and loss of power in her lower extremities. On interrogating her relatives it was ascertained that her father, although an able man of business, was of excitable temperament, and had been subject to several attacks of what seems to have been acute mania. Her mother died while she was an infant, and nothing definite could be ascertained concerning her health. An aunt was stated to be of unstable mind. Her sisters are all of nervous and hysterical temperament, and at least one of her brothers has shown a tendency to inherit his father's mental disposition. The patient herself had evidently been a precocious child. It is stated that in extreme youth she always exhibited unusual sharpness and intelligence, generally employed for mischievous or destructive purposes. Her stepmother, who is a remarkably sensible person, and her elder

sisters describe her as having always been a "very naughty child" who took a special delight in annoying and playing malicious tricks on her companions and relatives. She menstruated at the age of eleven, and has continued to do so regularly until her illness. Since that period she has been unusually developed, physically and mentally, for so young a person, and she still retains her reputation for wilfulness, cunning, and bad temper, although she can make herself amiable and agreeable when she pleases. She has been constantly engaged in reading novels and literature of an exciting and amorous character, and her mind seems to have dwelt incessantly on such subjects, as evidenced by her conversation and conduct. It was also markedly apparent that she did not behave to the opposite sex with the caution and modesty customary in persons of her position in society. On several occasions she was detected in more than equivocal relations with men, and it is stated that she was at least on one occasion overheard making indecent overtures to her own brother. Although, as a rule, she affected to despise the society of her own sex, she had one or two very special friends at her different schools, and the relations between them gave rise to very grave suspicions. From a German school, where certain minor indiscretions, not of a very reputable character, were proved against some of her companions, she was expelled, and it was stated by her schoolmistress that her offence was so bad that she declined to give an explanation for her dismissal, and her parents knowing her habits did not press for a reason. Subsequently she went to a school at a fashionable watering-place near London, where her behaviour was characterised by general misconduct. At various times she had fits of laughing and crying, and the irregular movements associated with a nervous attack. In October, 1875, and while apparently in good health, she declared that she had become suddenly blind. As this occurred immediately after correction for mutinous conduct, and as she had got the reputation of being extremely cunning and wilful, the schoolmistress and others thought she was malingering. A medical man called in, stated that he could find nothing the matter with her. Some few days afterwards she completely recovered her sight. This still further seemed to indicate that her alleged complaint was either intended or imaginary. She spent her Christmas holidays at home, accompanying her family to evening parties, &c. She was then seen by a London physician, who stated that she was hysterical, and who ordered strict moral control and cold baths. On returning to school, which it seems she disliked, she again stated that she had become perfectly blind,

and in addition deaf. She continued for some weeks in this condition when her hearing became completely restored, but the blindness remained. She was attended at different times by several practitioners, who agreed that the symptoms were of an emotional or imaginary nature, and that the patient was hysterical, and they ordered appropriate treatment. About February, 1876, she stated that she very rapidly lost the power in her lower limbs, and that she could not walk. This, it was supposed, indicated her desire to avoid the daily walks which she disliked, and to have drives instead. With this also the deafness returned. In this state she continued till April 1st, when I saw her for the first time.

The condition of the patient was then as follows:—A tall, full-grown, highly-developed, healthy-looking young woman. She stated that she was quite blind in both eyes. A variety of methods were tried to test this, but without any definite results. The pupils were both widely dilated, and very sluggish in their movements. On ophthalmoscopic examination, with the exception of the vessels of both discs being very slightly congested, the appearances were normal. She also stated that she was completely deaf in the right ear and partially so in the left one, so that one had to talk loudly to be heard. I observed, however, that on some days she could hear perfectly well. Examination of the ear revealed nothing. She complained of slight weakness of the lower limbs, and that she could walk only with the greatest difficulty. On examining these they were found of good muscular development. When lying on her back, motion and sensation seemed perfect, but at times there was hyperæsthesia of the skin of the legs. When she walked she staggered and moved about awkwardly, and stated she felt as if her legs gave way under her. There was no tenderness or abnormal condition of the spine. She stated that she suffered frequently from severe headaches in the occiput, which, however, were not constant, and lasted only a few hours at a time. The memory and intellect of the patient were in no way affected. She described all her symptoms with the greatest minuteness and exactitude. She had that manner of exaggerating her ailments so common in nervous persons. She cried out if her foot was touched, but on taking her attention away from it, firm pressure could be made without causing her to wince. The pulse was 100. The extremities were cold and blue. Temperature normal. Tongue slightly furred. Bowels constipated. Appetite good. She had not menstruated since her illness commenced, otherwise all the other systems were normal. On subsequent

investigation there was abundant evidence that masturbation was practised to a very great extent.

The diagnosis being uncertain, no active treatment was adopted. General hygienic and dietetic measures were suggested till the case had been further observed. The above conditions remaining, an eminent London physician saw the case with me. He came to the conclusion that it was one of aggravated hysteria, and gave as his opinion that little was to be done except placing her under judicious moral control. A respectable and experienced nurse was engaged to look after her under my direction, the patient remaining at home. There was no special medicinal treatment, except occasionally simple domestic remedies. She in no way improved. Every now and then she had attacks lasting from one to three hours which had all the appearances of hysterical fits, involving shouting, laughing, crying, throwing herself about, striking the nurse, &c. On April 15th, her blindness remaining as before, she stated that her deafness had so increased that she could only hear with the greatest difficulty. The nurse said that at times she could hear quite well. She could now hardly walk, and could only with difficulty crawl from one room to another with assistance. On four or five occasions another physician saw her with me, and after considering her condition from every point of view he was of opinion that it was a case of hysteria. On April 25th she became restless and greatly excited, chiefly at night, and frequently alarmed the household by crying out and getting out of bed. Change of air and scene were judged advisable, so she was boarded in a private house in the suburbs of London. The excitement continued to increase till on the 28th there were wandering and delusions. She was now totally blind, deaf, and could not stand or move her limbs. She did not know any one, and passed the contents of the rectum and bladder in bed. Her appetite failed; she complained of violent headache: her pulse was 140. Temperature could not be ascertained. On May 1st she became unconscious, and wildly delirious, raving chiefly about some faults she had committed at school, about babies and their birth, tying the umbilical cord, &c. Pulse 150. These symptoms continued till the 4th, the patient becoming gradually weaker. In the afternoon she appeared quieter; and at my visit about 5 P.M., I found her seated in an armchair by the fire. It was obvious she was very feeble. Shortly after this she became suddenly comatose, and in spite of every effort to support her strength with nutrients and stimulants, she gradually sank at about 2.45 A.M. next morning.

At the Autopsy, which I had the greatest difficulty in

obtaining, Dr. Robert Lee kindly assisted me. We found the body well nourished, and all the organs healthy, except the brain. On removing the calvarium, the pia mater was found deeply congested, and scattered over its surface were found five or six tubercular-looking bodies about the size of small millet seeds. The vessels on the surface of the brain were greatly engorged with blood. On removing the cerebral lobes in thin slices, a tumour was discovered in the right hemisphere. On further manipulation this mass was found to be about the size and shape of a hen's egg, of a dark grey translucent colour, and of nodulated appearance. It was of soft consistence, highly vascular, and on its surface were small extravasations of blood. It occupied the medullary substance of the middle lobe superior to the lateral ventricle, with the cavity of which it did not communicate, although it caused a marked bulging of its roof. As it was inconvenient to make careful observations and dissection in a private house, the whole brain was removed and taken away for subsequent investigation. Having to leave London the same night for some days, I left the preparation in the hands of a medical friend to preserve; but on my return I found that, owing to some mistake, the specimen had been unfortunately destroyed, so that I had no opportunity of investigating the exact relations and structure of the tumour.

Commentary.—From the commencement of her illness this patient had been looked upon and treated by her relatives and medical attendants as a wilful and cunning hysterical subject. At first sight, considering all the circumstances of the case, I confess my own impression was in accord with this idea. At the same time I reserved my opinion, and, seeing the case was a grave one, no active treatment was employed, and I had considerable difficulty in persuading her relatives that under any circumstances her condition was one of disease, and not of malingering. Subsequent observation convinced me that there was some serious organic mischief in the brain, although I did not attempt to define its exact anatomical characters. Dr. Russell Reynolds says that to confound hysteria with tumour of the brain indicates either "carelessness, or a prejudiced view of dealing with the obscure affections of women." Such was certainly not the case in the present instance, as this patient's condition was most carefully and impartially investigated from every point of view, and she had the benefit of being several times most attentively examined by one of the first authorities in Europe on nervous diseases.

The following circumstances seem to have weighed with the different medical men under whose care she had been, in

making the diagnosis of hysteria. The family history, the patient's age, whole life and character, her sentimental and romantic disposition, her precociousness both mental and physical, her abnormal sexual passions (which were known to be gratified in an illegitimate manner), and her irregular menstruation. The circumstances of her actual illness also were anomalous. The sudden attack of total blindness—she being in apparently robust health—at school while angry and sulky after correction for misdemeanour, the equally sudden recovery of sight some days afterwards, the sudden loss of sight a second time and deafness, the restoration of hearing, the loss of power in her lower limbs, the subsequent total blindness, deafness and paraplegia. The absence of severe constant headaches, of strabismus, ptosis, diplopia, of facial or lingual paralysis, of convulsions, vomiting, wasting, of abnormal ophthalmoscopic appearances, and many of those symptoms so frequently associated with tumour of the brain. Finally the dilated pupils, the hyperæsthesia of the skin; the fact that she had had attacks of laughing, crying, and throwing herself about—all occurring in a healthy young woman of good appetite and strong muscular development, and whose appearance and character were eminently suggestive of what is described as hysterical,—gave rise to the view that the case was one rather of emotional than of organic disease.

When the facts of the case are examined, it will be seen that for some years the patient had been in what is called a hysterical state, by which I apprehend is understood a condition occurring in women of the nature and morbid lesion of which we are ignorant. How far this state was owing to the presence of the tumour it is impossible to say, as it cannot be even surmised when this commenced to grow. It was not till October, 1875, that any definite symptoms of pressure manifested themselves, and we must assume that by that time the tumour had reached considerable dimensions. If the disease was of slow growth, it remains an important question how far the previous so-called hysterical symptoms were connected with its presence. If we admit any such connections, it would indicate that organic disease in the brain is capable of inducing those anomalous disorders to which are applied the terms functional and hysterical. If this be so, this case is further evidence to those who think with me that this so-called hysteria is the result of some definite nervous structural change, with the nature of which we are as yet unacquainted, and, whether due to direct alteration of tissue, or to modification in the circulatory or nutritive processes, remains yet to be demonstrated.

There are other features in this case which are somewhat unusual, and difficult of explanation. The fact that while in good physical health, and previously having had no definite symptoms, the patient becoming one day while angry suddenly blind, can, I apprehend, only be explained by assuming that the tumour had reached a certain size without producing any special effects of pressure, being situated as it was in the medullary portion of the hemisphere. While in the angry fit, the growth, which was afterwards found to be very vascular, must have become engorged with blood, or there may have been hæmorrhage from some of its vessels, hence the sudden blindness. The congestion subsiding, or the blood-clots becoming absorbed, the sight gradually returned, to be followed before long by a similar recurrence, and subsequently in addition by deafness and paraplegia, all of which fluctuated in intensity.

Paralysis of both lower extremities without any other motor nerves of the body being affected, also is difficult of explanation, and we can only assume that the tumour by pressure caused such venous congestion in the pons or other parts of the brain as to bring about this symptom. The case would also seem to support the recent views of Dr. Brown-Séquard on "Paralysis from Brain-disease."

It is unfortunate that the specimen was accidentally destroyed, as it would have been interesting to know its structure and exact relations to surrounding parts.

In conclusion, there appear to me to be at least two points of interest in this case: 1st, the anomalous symptoms of pressure caused by the tumour; and 2nd, that symptoms of what is called hysteria may co-exist with organic disease of the brain—whether independent of it or the result, being in this patient doubtful. Under any circumstances it serves to indicate what caution should be exercised in diagnosing, and more especially in treating as hysteria, any nervous affection in women which may appear indefinite or mysterious.

TWO CASES OF LEAD PALSY, WITH REMARKS ON THE DIAGNOSIS.

BY THOMAS BUZZARD, M.D.,

Physician to the National Hospital for the Paralysed and Epileptic.

ABOUT a year ago a married lady was brought to me by her medical attendant, complaining of great loss of power in the right hand and left foot, which had been gradually increasing for three or four months; and was then so confirmed that she dragged her foot, and could do nothing with her hand. She was 26 years old, healthy looking, and the mother of three children, of whom the youngest was two years of age.

On examination, the right forearm, at a point four inches below the olecranon, was found to measure $7\frac{5}{8}$ inches, as against $8\frac{1}{4}$ inches, the size of the left at the same level. The plump of the thumb, too, of the right hand appeared somewhat thin, and the interossei depressed. The hand could not be brought to a level with the forearm. Its grasp was feeble, and the patient could not perform delicate movements with the fingers. The left foot dropped when lifted off the ground. On the other hand, there was nothing wrong, so far as could be observed, with the left upper and the right lower extremity. This *bizarre* arrangement of the paralysis had suggested to more than one medical observer that the affection was of an hysterical character. The general health was described as fairly good, except that there had been occasional vomiting. The patient was not constipated, nor had she suffered from colic, and careful examination failed to show the slighest trace of any blue line in the gums. Enquiry had not succeeded in eliciting any history of exposure to lead.

When the excitability of the muscles came to be tested by electrical currents, important changes were observed. On the right side none of the muscles on the back of the forearm would respond to the highest strength of induced currents which could be borne, except two. The supinator longus con-

tracted freely to a moderate strength; and the supinator brevis, which, owing to the wasting, could be picked out by the rheophore between the short radial and common extensors, answered readily enough to the stimulus, producing brisk supination of the hand. The intrinsic muscles of the hand likewise failed to respond to Faradaism. To a voltaic current from eight cells of a Stöhrer's battery, slowly interrupted, all the muscles which had been unaffected by the induced currents contracted freely; whilst the supinators showed no response to this stimulus, which is not sufficiently strong to affect healthy muscles.

The left leg presented similar inexcitability to Faradaism, coupled with active response to weak voltaic currents in the tibialis anticus group of muscles.

In the left forearm, which presented no obvious lesion, it was found, nevertheless, that the excitability to Faradaism was below the normal in the extensor communis digitorum.

In the right leg, too, there was slight diminution of excitability to Faradaism, but in neither was there exaggeration of irritability to interrupted Voltaism. There was slight loss of electro-cutaneous sensibility in the right forearm and left leg.

The result of examination thus made it evident that the patient was suffering from lead poisoning, and a confident opinion was accordingly expressed to this effect. But the possibility of such a cause was at first strongly denied, both by the patient and her husband. It was only after persistent enquiry that the following fact was elicited. About three weeks previously, the zinc cistern supplying the patient with drinking water had been cleaned out, and three or four feet of lead-piping was found lying loose in the bottom of it, having been dropped there by a careless workman. How long it had lain there could not be ascertained, but it must certainly have been many months.

A few months later a middle-aged lady was sent to me by a medical friend on account of powerlessness of the hands. The weakness, it seemed, had commenced more than five years before, and had gradually increased so much that she had come to have great difficulty in doing anything with her hands. In the course of her long illness she had been seen by several medical men, who had pronounced her, so I was told, to be suffering from Cruveilhier's atrophy affecting the muscles of the hands. She had not had any electrical examination.

There was a helpless look about her hands, which "dropped" somewhat, and could not be kept perfectly extended. The forearms were round—somewhat plump-looking indeed—and

in contrast with them the hands appeared to be wasted more than a closer observation showed them really to be. The fingers could be moved freely enough in various directions. The patient had pains in them occasionally. There was no flattening of either forearm, but the flesh when handled felt pulpy, and wanting in firmness. Whilst the hand could not be extended against even a very slight opposition on the part of the examiner, the movement of supination was performed readily, and with good force.

Electrical examination showed the excitability to Faradaism to be very much diminished in the extensor communis digitorum, extensor indicis, and extensores carpi radialis longior and brevior; not so much, but still appreciably lessened in the extensor carpi ulnaris. The supinator brevis could not be reached—the supinator longus reacted to Faradaism. The intrinsic muscles of the hands reacted to Faradaism equally well on each side, and if there was any diminution of excitability in them, it was but slight. There was an indefinite history of impairment of general health, and the occurrence of occasional spasms of the bowels. An opportunity was not afforded me of examining the gums.

An opinion was given as the result of this examination that the case was one of lead poisoning. On enquiry as to exposure, it appeared that the patient had been in the habit for many years of applying to her head one of the popular "hair restorers," the active ingredient in which is known to be lead. The quantity used at a time was said to be small (which is a relative term), but its application had been constant.

A history of exposure to lead, the presence of a blue line on the gums, preceding colic, and the peculiar character of the affection, are features commonly adduced as the diagnostic signs of lead palsy. The history of exposure, however, has often to be sought out by pertinacious enquiry after the diagnosis has been formed through other sources. So again the blue line may be wanting, and there may have been no colic. It is, then, to the peculiar character of the palsy, and especially to the effects of electrical currents on the muscles, that we have usually to look for the most valuable—the only reliable evidence, indeed, of the nature of the disease. The cases described seem to me worth recording as illustrations of the value of these signs.

In both the examination by means of electrical currents gave results in accordance with Duchenne's well-known description of the characteristic signs of lead palsy. The excitability to Faradaism was absent or sensibly diminished

in all the muscles of the forearm, except the supinator longus and brevis. The fact that those muscles were not included in the paralysing influence was shown in two ways—1st, when the patient had semipronated the hand, and then flexed the forearm on the arm, the observer tried to extend the forearm against her resistance, when the supinator longus could be felt contracting strongly; 2nd, by testing the muscles with induced currents, when it was found that they retained their normal excitability. The opportunity which I have had of observing a considerable number of cases of lead palsy has shown me that the signs noticed are those which are commonly found. Duchenne went so far, I think, as to say that he had met with no exception to the rule that the supinators were exempted, and writers have repeated his description. But the rule is not quite without exception. I have seen some well-marked instances of the supinators taking their share in the common lesion. These have been, however, comparatively very few indeed, and have always occurred in cases where the exposure has been long continued, and when, if I am not mistaken, some muscles of the arms, as well as the forearms, were involved in the atrophy. So that for all practical purposes, Duchenne's rule appears to me one to be depended upon—at least in cases which are not of very old standing indeed, or of exceptional severity.

In health, the supinator brevis cannot be directly faradised on account of its deep position. But in lead palsy it very often happens that the wasting of the extensor communis digitorum has proceeded far enough to uncover the supinator brevis sufficiently to allow a small rheophore to be applied to it. Under these circumstances the electrical diagnosis is singularly simple, and can be carried out in about the space of a square inch at the upper and back part of the forearm. If it be found (both arms being affected) that the common extensor fails to respond to Faradaism whilst the short supinator close by, on a lower plane, is readily excited by it, the case may be positively set down as one of lead palsy.

The exaggerated reaction to Voltaism in the first case is not at all unfrequent in cases of lead palsy of not long standing.

The crossed arrangement of the paralysis in the first patient is curious; and had the apparent exemption of one leg and one arm on opposite sides been as real as it looked, explanation of the anomaly would probably have been impossible. But the electrical examination showed that the difference was in truth one of degree only. The apparently sound limbs betrayed characteristic signs of lesion in the diminished excitability of their muscles, and it was evident that time only was required for them to share the trouble of their fellows. It is much more

common than not in cases of lead palsy for one limb to suffer more than the other. In this instance, however, the contrast was more than usually strong.

It is an interesting fact, that in the apparently sound limbs, there was diminution of electric excitability in muscles which, according to the patient's own feeling, had nothing the matter with them.

In the second case the absence of any flattening of the forearms—their marked roundness, indeed—was likely at first sight to cast doubt upon the probability of there being any atrophy of the extensor muscles. But although in many cases of lead palsy, especially in those of rapid and recent occurrence, there is an amount of excavation which is quite remarkable in the situation of the extensor group, yet in those of old standing one often sees that the affected limb wears a false air of nutrition. It is known that this depends upon a large interstitial development of adipose tissue separating and surrounding the wasted and degenerated muscular fibres. No doubt this had happened in the present instance, where the disease, although not very extensive, had existed more or less for some five years.

The entire absence of the blue line in the gums of the first patient is noteworthy, as it tended to obscure the diagnosis. Although the absence of this sign is not by any means unexampled, it is certainly rare in a case of lead-poisoning so marked as this was, to find no characteristic discoloration in the gum. I explain its absence here by the fact of the exceeding care which the patient had evidently taken in brushing her teeth, which were scrupulously white and perfect. As Mr. Tomes has described, it seems likely that it is to the decomposition of portions of food left about the margins and interstices of the teeth, and in the tartar often collected there, that the discoloration is due, sulphuretted hydrogen thereby formed acting upon the lead in the neighbouring tissue. It is worth remembering, as this case well shows, that the blue line is not a necessary feature of lead-poisoning in persons of cleanly habits. Probably the converse is still less to be depended upon. The presence of a very well-marked lead line is quite consistent with health. Some time ago I examined a number of men employed in lead-mining and lead-smelting in Derbyshire. They had all more or less of a blue line in the gum and their complexions were generally pale. but none had any complaint to make of their health. Lead-poisoning, indeed, is as rare amongst the men thus engaged as it is common among those who are employed in the manufacture of white and red lead.

CASES OF CEREBRAL EXCITEMENT TREATED BY MUSTARD BATHS.

BY A. R. URQUHART, M.D.

SOME thirteen years ago it occurred to Dr. Newington that the mustard bath, which he had seen employed in hydropathic establishments with considerable benefit as a derivative in cases of apoplexy and cerebral congestion, might prove useful in lunatic-asylum practice. After various experiments he resorted to it in a case of mania, and with such satisfactory results that he has since had recourse to this remedy very frequently when desiring to allay excitement or induce sleep. It is thus administered.

A quart of Durham mustard bran having been infused in boiling water for half an hour, the patient is placed in the ordinary hot-water bath (the privates being protected with a clean sponge), and the infusion then poured in through a coarse hair strainer, and well diffused throughout the bath. A blanket should now be arranged to retain the heat and fumes of the mustard, and the patient watched by the medical attendant. From ten to fifteen minutes will generally be found long enough to redden the skin slightly, and induce its free action, and as soon as this is obtained no time should be lost in wrapping the patient in a blanket, and placing him in bed.

Amongst the therapeutic effects of the mustard baths the following are most noticeable:—

(1) Excitement of the peripheral nerves; (2) determination of the blood to the skin; (3) derivation of the blood from the brain; (4) inclination to sleep; (5) increase of temperature; (6) lowering of the pulse; (7) diminished sensation; (8) diminished motor powers.

The excitement of the peripheral nerves is peculiarly persistent, evidenced by tingling sensations in the skin, sometimes lasting throughout the day following the bath. And

this persistent action is also seen in the hypnotic effect—two or even more nights of refreshing sleep resulting from one application. The skin usually acts very freely, so that it is advisable to guard against chills, and to allow the patient to remain in bed next day. The lowering of the pulse is not a constant feature, though its frequency will usually be found to be diminished from ten to twenty beats a minute.

Of its value as a hypnotic these two cases may be taken as illustrative:—

Case I.—A young lady, labouring under acute mania, had been sleepless for seven nights previous to admission, in spite of the free administration of narcotics. She was placed in the mustard bath for twenty minutes, and thereafter enjoyed a refreshing sleep for five hours. Next evening the bath was repeated, and was followed by nine hours' sleep, the patient awakening comparatively rational, and expressing herself as feeling much more comfortable.

Case II.—A middle-aged lady, suffering from recurrent mania with insomnia, is nearly always calmed by a mustard bath, the attacks being undoubtedly shortened, and sleep being readily gained.

The following illustrates the value of the mustard bath as a derivative:—

Case III.—A gentleman in the advanced stage of general paralysis with epileptiform convulsions followed by lividity, unconsciousness, and rigidity, was treated by being enveloped in cloths wrung out of the mustard infusion covered with macintosh. In half an hour the face became pale, the rigidity passed off, and consciousness returned. And this effect has been noted and found of great service in many similar cases of general paralysis.

The cleanliness, safety, and efficiency of this valuable hypnotic and derivative merit a wider trial in asylum practice than it has hitherto obtained; and whatever persuasion is requisite to induce a patient to undergo this method of treatment for the first time will be quite unnecessary on a second occasion.

Abstracts of British and Foreign Journals.

On the Structure and Functions of the Nervous System. Dr. James Ross (*The Medical Times and Gazette*, Oct. 27, *et seq.*).—The first paper is occupied with preliminary remarks on the proportion of living matter, the general conclusion being that nervous tissue is with respect to structure a mere differentiation of embryonic tissue, and with respect to function a specialisation of the common properties of all living matter. The next paper (Dec. 8th and 15th) deals more specially with the fundamental properties of the nervous tissues. Nervous tissues are composed of cells and fibres, the former originating and the latter conducting motion. The cells vary in size, and the larger the cell the more nearly related it is to the outgoing currents; and conversely, the smaller the cell, the more remote it is from these currents. Caudate cells with many processes and definite connections, are also in relation with outgoing currents, and occupy positions where numerous actions have to be grouped and co-ordinated. Bipolar cells occupy positions where the actions to be co-ordinated are few in number and uniform in kind. Cells with few processes, and without any definite connections, are in relation with the incoming currents. There are three kinds of nerve-fibres: the first being represented by an axis cylinder; the second by neurilemma and axis cylinder; and the third by neurilemma, medullary sheath and axis cylinder. The progress of development is from the simple to the complex; hence from the first to the third kind of fibre; and from the round cell without processes to the caudate cell with processes and definite connections. The first kind of fibre will be found where the actions to be grouped are diffused, the second where they are more definite, and the third where they are exceedingly definite. The third paper (Dec. 22nd and Jan. 12th) deals with the fundamental properties of the nervous system. The fundamental law of nervous construction is that as unlike parts have unlike functions, so

every distinct part of the organism will have a distinct function presided over by a distinct nervous centre. On the other hand, where structures, originally separate, have become fused in the course of development, their functions are also fused, and there is a similar fusion of their nerve-centres. The fourth paper (Feb. 9th and 16th) discusses the spinal cord. The white part of the cord which in the adult appears to be uniformly of the same structure, has, by embryological and pathological investigations, been analysed into six distinct systems for each lateral half. In a human fœtus of a month old the cord consists of grey matter disposed round a central canal, and four bundles of fibres, two for each side; the anterior couple being disposed round the anterior and the posterior round the posterior roots of the nerves; hence they are called the anterior and posterior root-zones respectively. The grey substance (which may be called the "central grey tube") and the root-zones represent the spinal system, and are the only portions present in the amphioxus. Both of these vary in size according to the number and variety of the actions to be co-ordinated; the remaining portions connect the central grey tube with the cephalic centres, and they increase steadily from below upwards. Two of the remaining four systems may together be called the pyramidal fibres, inasmuch as they come together to form the anterior pyramid of the medulla. These fibres take origin in the cells of the central convolutions of the cerebrum, and pass uninterruptedly through the corona radiata, internal capsule, crusta, and pons, to reach the anterior pyramid of the medulla. A variable number of the external fibres of the pyramid pass directly down the cord close to the anterior fissure forming the column of Türck. By far the larger proportion decussate with those of the opposite side, and proceed backwards and downwards to reach the posterior aspect of the lateral column close to the posterior cornu; hence these may be called the pyramidal fibres of the lateral columns. All the pyramidal fibres terminate in the cells of the anterior horns. A fifth bundle occupies the lateral surface of the cord external to the pyramidal fibres. These connect the cells of Clarke's column and the cortex of the cerebellum, and are called the direct cerebellar fibres. The sixth system is a wedge-shaped bundle called the column of Gall, which lies between the posterior root-zone and the posterior fissure; its fibres ascend and end in the nucleus of the slender fasciculus of the medulla, but their origin in the cord has not been ascertained. The anterior white commissure may probably be reckoned as a seventh system.

The Localisation of Cerebral Disease, *being the Gulstonian Lectures,* 1878. First Lecture. DAVID FERRIER, M.D. (*British Medical Journal,* March 23 and 30, 1878.)—The obscurity and confusion which still embarrass the study of cerebral diseases are to be attributed, in great measure, to the facts—(1) that many functional nervous disorders leave no discoverable trace behind them; (2) that interference with the brain at any one point tends to general functional disturbance; (3) that the discoveries of experimental physiology are not altogether consistent with clinical and pathological observations. The principles which must guide research, and determine conclusions, in the localisation of cerebral diseases are—(1) that one clear case in which destruction of a cerebral region caused no interference with the function assigned to it, must overturn a large amount of positive evidence in favour of this particular localisation; (2) that it is not always necessary, when certain functions are deranged, to show organic lesions in the parts in which these functions are localised; (3) that the symptoms observed with a cerebral lesion are not necessarily the result of derangement of functions in the parts immediately affected; (4) that any statement which contradicts our uniform experience must be regarded with suspicion, and received only when it has satisfied all the requirements of scientific evidence.

Brain functions may be investigated objectively and subjectively, and present themselves under physiological and psychological aspects. Brain diseases are manifested as mental aberrations, and as affections of motility and sensibility, but these classes of functions are rarely equally involved. Regarding the intimate pathology of insanity we know nothing, nor shall we attain to any practical acquaintance with it until the various morbid appearances, discoverable in the brains of the insane, are translatable into their subjective signification. Because large tracts of brain cortex may be destroyed without evident mental disturbance, and because any one part of the brain may be destroyed with a like negative result, it has been alleged that there is no localisation of function in the brain. But to show this it is necessary to demonstrate that the same part may be destroyed in both hemispheres without mental disturbance. But this has never been done. We have no evidence proving satisfactorily that even in a unilateral lesion the mental powers are unscathed.

Brown-Séquard has disputed the validity of the law of cross-action of the cerebral hemispheres, on the authority of two hundred cases of paralysis occurring with disease of the brain; but for

every case of direct, nine hundred and ninety-nine of cross-paralysis might be cited. All that is proved by these cases is that the law of cross-action is an approximative generalisation instead of an absolute rule. But in many of the cases of direct paralysis there were sources of fallacy, and the law of cross-action has an enormous preponderance of evidence in its favour. Paralysis, however, on the same side as the cerebral lesion, may be regarded as a possible occurrence on anatomical grounds. Flechsig has shown that the pyramidal strands are subject to considerable variations in respect to their decussation in the medulla oblongata. As a rule the most of the fibres of the pyramid descend in the postero-lateral column of the opposite side: the rest on the antero-internal of the same side. But occasionally the rule is reversed, and in one case there was no decussation at all.

Various attempts have been made to establish connection between lesions of certain cerebral organs and certain symptoms bodily or mental. Bouillaud with profound insight declared that several motor-centres exist in the cerebrum. But to Hughlings-Jackson belongs the credit of having first indicated the motor functions of certain regions and given a rational explanation of the phenomena of unilateral cerebral convulsions. Instead of trying to account for the phenomena by transmission of some influence to distant motor regions, he regarded certain convolutions as themselves motor. No direct evidence could however be adduced in favour of this view until Fritsch and Hitsig showed in 1870 that electrical excitation of certain regions of the cortex invariably produced movements on the opposite side. In spite of innumerable attempts to degrade the grey matter of the brain and to exclude it from all share in the results, it may be regarded as established that its definite groups of cells yield definite effects always constant under definite stimulation of whatever nature. It is the great characteristic of the reactions which ensue on the application of the electrodes to the cortex that the results are definite, uniform and predictable when the electrodes are on one region, while there is a sudden transition to another movement equally constant, definite and predictable when the electrodes are shifted to a spot immediately adjoining the former. This remarkable and established fact is incompatible with the theory of physical conduction. Electrisation of certain parts close to the basal ganglia, as the island of Reil, is absolutely negative, while electrisation of more distant parts, as the postero-parietal lobule, produces immediate movement. This also is incompatible with the conduction theory, which is however mainly

rested on the observation that after removal of the grey matter, the application of the electrodes to the cut medullary fibres produces exactly the same movements as before. But there is plurality of causes. As well might we disprove in succession the motor functions of the corpus striatum, crus cerebri, spinal cord and motor nerves, because we can produce the effects attributed to their activity by direct stimulation of the muscles themselves.

The facts that the interval which elapses between an electrical excitation and a movement diminishes when the grey matter is removed, that under these circumstances a stronger stimulation is necessary than when the cortex remains entire, and that after a certain period the excitability of the medullary fibres denuded of cortex disappears, establish beyond doubt the relation of the cortical grey matter to movements.

Anatomical homologies must only be used in support of identity of functions with great caution. Experiments on the lower animals, such as frogs, pigeons, rabbits and dogs, give results but little in harmony with those obtained by experiments on higher animals which in conformation and habits most closely approach man. It may be shown, however, that in experiments on the cerebrum, what is true of monkeys is strictly true of man also. All experiments on different animals point to this conclusion, that the same movements are represented, though with different significations in different centres higher and lower. Volitional movements are those alone which are necessarily paralysed by destruction of the cortex; while automatic, instinctive or responsive movements are more or less completely and independently organised in the centres situated below the cortex. The conclusion to be provisionally drawn from the results of experimental physiology is that there are certain regions in the cortex to which definite functions can be assigned, and the phenomena of cortical lesions will vary according to their seat and also according to their character, whether irritative or destructive. In tracing out the effects of lesions of the human brain, the strictest topographical accuracy as to their position and limits is of vital consequence. For want of this the great mass of old records of cerebral disease is valueless.

The frontal lobes, lesions of which are to be first considered, give no motor reaction when subjected to electrical irritation in the monkey. Destruction of these lobes causes no paralysis of motion or sensation. Many cases are on record of extensive lesions of these lobes in the human subject, with like negative results. One of the most remarkable of these is the American crow-bar case: A

young man, while blasting had an iron bar, 3 ft. 7 in. in length, and $1\frac{1}{4}$ in. in diameter, propelled through his head, in a line from the left angle of his jaw to a point near the sagittal suture in the frontal region. Within an hour of the accident he walked up a flight of steps. He ultimately recovered, lived twelve and a half years, and died of epileptic convulsions. His skull has been preserved, and an examination of it leaves no doubt that the whole track of the injury was included within the pre-frontal region, and that, therefore, the absence of paralysis, which has been commented on by Dupuy, was quite in accord with the results of experimental physiology. But the man's mental condition was radically changed. The equilibrium between his intellectual faculties and animal propensities was destroyed. From having been shrewd, energetic, persistent, and sedate, he became weak, fitful, capricious, and profane. Similar cases have been reported by Bouillaud, Trousseau, Congreve, Selwyn, and others, all proving that sudden and extensive lacerations may be made in the pre-frontal region, and large portions of brain substance may be lost, without causing impairment either of sensation or motion.

Cases of softening and abscess in the same region give the same results. In some of these, however, the psychological condition has attracted notice. Lepine says of a case of abscess of the right frontal lobe: "He was in a state of hebetude, he seemed to comprehend what was said, but could scarcely be got to utter a word." Baraduc and Davidson have described cases of dementia following injury and atrophy of this region. Mental deficiency has been frequently noted in connection with arrested development of the frontal lobes.

Intelligent monkeys that have undergone removal or destruction of the frontal lobes retain their appetites and instincts, exhibit emotion, and preserve their senses and power of voluntary movement unimpaired; but they are apathetic and dull, do not manifest natural curiosity, are drowsy and listless, or indulge in purposeless movements. They seem to have lost the faculty of attention and intelligent observation, and the same kind of mental failure exists in general paralysis, in which morbid changes more particularly marked in the frontal lobes have been demonstrated.

A Human Cerebrum imperfectly divided into two hemispheres. Professor TURNER. (*Journal of Anatomy and Physiology*, vol. xii., January, 1878.)—The brain (which is figured) of an epileptic imbecile, who died in the Wilts County Asylum, presented

several points of especial interest and importance. The great longitudinal fissure was imperfectly developed; the two hemispheres were connected by mesial convolutions; there was only a single ventricular chamber, and the middle cornua to this ventricle were wanting; the corpus callosum, fornix, septum lucidum, velum interpositum and choroid plexuses were non-developed. To interpret the malformation of this brain by the usually accepted view that the cerebral hemispheres arise as distinct lateral vesicular offshoots from the anterior part of the wall of the anterior primary cerebral vesicle, we should have to suppose that the mesial convolutions were an excess of development of the grey matter in the longitudinal fissure. But the more recent and correct observations of His, and Mikhalovics—which show that the secondary forebrain is at first an unpaired vesicle hollowed out into one undivided chamber, ultimately partitioned by a notch deepening into a furrow, and forming the great longitudinal fissure—enable us to understand that the unusual appearances in this brain are indications of an arrest and not of an excess of development. The great longitudinal fissure has only been imperfectly formed, and consequently the separation of the original unpaired hemisphere vesicle into two distinct hemispheres has only partially taken place. The grey matter which in the normal development would by the downgrowth of the falx cerebri have formed the inner surface of each hemisphere has remained mesial, and constituted a connecting bridge across the fissure between the two hemispheres. The large primitive foramen of Monro has remained persistent, and the corpus callosum, fornix, and septum lucidum, all lying in the mesial plane, have not been formed. But notwithstanding the imperfect development in the mesial plane of the cerebrum, the grey matter on the surface of the hemispheres had assumed the arrangement into fissures, lobes and convolutions, characteristic of the human brain, and the mesial grey matter also had become convoluted. The basal ganglia were well developed, and the white matter of the corona radiata connecting these with the hemispheres was well formed, but the absence of the commissural fibres of the corpus callosum occasioned a diminution of the amount of white matter in the core of each hemisphere. The deficiencies in development enumerated had affected the size and weight of the organ. It weighed 39¼ oz., or about 10 oz. less than the average adult male European brain. It is not to be wondered at that this man exhibited evidence of imperfect intellectual capacity.

On the Expression of the Emotions. W. Wundt. (*Revue Philosophique*, August, 1877.)—After a short and interesting historical introduction, in which we must note in passing a suggestive comparison between Gall and Lavater, Wundt briefly examines the work of the great English naturalist—Darwin. If, he says, we owe to Darwin some acknowledgment of the way in which he has proved certain general facts, we cannot fail to recognise the point at which habit, even combined with the constitution of the nervous system, is insufficient to give the key to emotional expression, because habit explains everything, and therefore nothing.

Wundt makes no distinction between the feelings and their kindred sensations. Language in its ordinary metaphors sanctions this view. We say, "hard necessity," "sweet melody," "black cares," "bitter troubles," or "dark destiny." These images have their origin in our sensibility. Our organs of sense are furnished with muscles, which have the double duty of affording the best reception to favourable impressions, and of keeping at a distance injurious agents. The mouth takes a different expression according as we taste a sweet fluid or swallow a bitter drug. Darkness, a too bright glare, soft daylight, each gives in turn a new expression to the face; one makes us open our eyes wide, the second causes us to knit our brows, the third imparts to our countenance an air of serenity. Hence it results that agreeable or disagreeable sentiments, joy, pleasure, esteem, fear, grief, scorn, are manifested by muscular contractions which recall on one side the action of grateful tastes or odours, or the brightness of a moderate light; and on the other bitterness, a stench, shadows, or a blinding dazzle. Reciprocally the expression gives rise to the feeling; the actor who simulates anger becomes to some extent angry. On the same principle depends another class of expressions—those gestures by which our ideas and representations are accompanied, and which serve to arouse in others similar ideas and representations.

Neuro-Syphilis. Edward Wigglesworth, M.D. (*The Boston Medical and Surgical Journal*, February 28, 1878.)—As nervous diseases of syphilitic origin are more amenable to treatment than the corresponding idiopathic ones, a correct diagnosis may at times be sufficient to save a life which would otherwise be lost. Syphilitic affections of the nervous system are late forms. Traumatic injuries or depressing emotions act frequently as exciting causes, while a powerful predisposing cause is an unsystematic or insuffi-

cient treatment of the disease in its earlier stages. Cerebral syphilis may appear as (1) Successive hyperæmic attacks, with symptoms like those of general paralysis. (2) Syphiloma accompanied by paroxysmal and intolerable nocturnal headache, and by sleeplessness, especially in young persons, in whom insomnia from other causes is rare. (3) Disease of the arteries, followed by apoplexy or thrombosis, with necrobiosis and syphilitic hemiplegia, after which recovery under the best treatment is generally imperfect.

Two Cases of Nerve Stretching. Dr. Thomas G. Morten and Dr. William C. Cox. (*The American Journal of the Medical Sciences*, January, 1878.)—Miss B. accidentally ran a pair of scissors into the outer side of her right wrist, and suffered in consequence intense pain in the hand and wrist, gradually involving the elbow, shoulder and side. The pain was never absent, but was subject to exacerbations, and was increased by pressure. The application of laudanum blisters, belladonna and aconite gave no relief. Sewing and writing were especially painful; there was also a sensation of numbness and cold in the hand. Three months after the injury an incision was made at the wrist, directly over and in the line of the ulnar nerve, which when isolated was found quite normal in appearance. The forefinger was passed under the nerve, and it was well stretched. When it was replaced it was seen to be considerably lengthened, and to present a wavy outline. The pain in the arm after the operation was intense, and in a few days an abscess formed in the upper part of the wound. For several weeks a feeling of numbness and tingling continued in the little and ring fingers, and on the outside of the hand, but these symptoms gradually disappeared, and in a month all pain had ceased. No symptoms of impaired nerve action followed, sensibility and muscular power remaining perfect. The second case was that of a carpenter, who, having fallen from a scaffold in 1866, suffered subsequently from concussion, difficulty of speech, paralysis of both legs, and acute articular rheumatism. The paralysis of the lower limbs gradually disappeared, but after it there came on excruciating pain in the sole of the left foot, with no swelling, constitutional disturbance, nor increase of pain on pressure. There was loss of sensation in the foot and half-way to the knee; temporary relief was obtained from morphia, but ultimately Dr. Casselberry excised a portion of the plantar nerves, which gave complete ease for seven years. In 1874, however, the pain recurred, and involved the leg as well

as the foot. By pain and morphia the patient's health became utterly broken down. On June 12, 1877, after etherisation, an incision was made over the sciatic nerve in the middle of the thigh, and then it was thoroughly stretched. For five days there were spasms of the muscles of the legs with exquisite sensitiveness along the sciatic and popliteal nerves, but this gradually subsided. Pain in the old locality, however, still continued, and morphia was used daily. Some weeks after this, the suffering being very great, two inches of the external popliteal nerve were excised, and this is said to have given entire relief.

In the case of the ulnar nerve-stretching the increasing pain, which had not only involved the hand and arm but had extended to the neck and side, was entirely relieved by this operation, which inflicts far less injury than any nerve excision. In the case of the sciatic nerve-stretching the operation did not give relief.

J. Crichton-Browne.

The Influence of the Spinal Cord upon Animal Heat. (*Archiv. de Phys. norm. et. Path. n.* 1 *et.* 2, 1877, *et Revue des Sciences Médicales.*)—M. Parinaud, finding that section of the spinal cord lowered animal temperature—a fact previously well established—formed this hypothesis. The effect is produced by means of two sets of nerves, the vaso-motor and the trophic. Paralysis of the former elevates the temperature; paralysis of the latter lowers it. The author rests this explanation upon the fact that section of the cord is followed by a lower temperature in the groin below the section than is observed in the axilla, above the section; the difference, however, not exceeding a few tenths of a degree. According to M. Parinaud, this diminution of temperature can be explained only by a lessening of the chemical combustions in the corresponding parts. The author explains the slower pulse and respiration after section, by supposing that the *necessities* of the chilled animal are fewer. Section of the cord does not act directly on the circulation, and after such a lesion the animal preserves in part the power of equilibriating its temperature. Disturbances in temperature are the same when the author divided the cord below the cardiac nerve, about the fourth and fifth dorsal vertebræ, as when the section was made at the level of the cervical vertebral. According to M. Parinaud, vaso-motor paralysis would explain the momentary increase of peripheral temperature observed immediately after section, and the considerable and persistent increase of temperature

often noticed in man after such lesions would be more probably due not to the section, but to the myelitis consequent on it.

[The author has originated an ingenious theory, but without offering much proof of its correctness.—TR.]

Clinical Researches on the Motor Centres of the Limbs. (*Journal de Thérapeutique*, 1877.)—M. Bourdon cites under this title a large number of interesting observations. An elderly man, weakly, and suffering from atheroma in the cardiac valves and arteries, is suddenly seized, after a simple faint, with loss of speech and a paralysis limited to the muscles of one of the forearms, without loss of sensibility. The nature and onset of the seizure had led to a diagnosis of lesion in the cortical brain-substance near and probably in front of the fissure of Rolando. After death a small bloody extravasation was found behind the upper part of the ascending frontal convolution, on the side opposite to the paralysis.

M. Bourdon's conclusions from a large number of interesting facts are the following.

The motor centre for the arm in man occupies a zone of the cerebral cortex comprehending the two ascending convolutions, the frontal and the parietal, and neighbouring parts; and is not, as experiments made on the lower animals would seem to imply, a limited and clearly bounded region of this zone.

The movements of the legs would seem to be under the control of the highest part of this zone.

The movements of the face appear to depend upon the back part of the second frontal convolution, and on that part of the ascending frontal convolution which is in the neighbourhood.

Amputation of a limb induces in time *atrophy* of the part of the cortical substance on which its movements depend.

According to the author it follows from these conclusions that in cases of paralysis limited to an arm, and of cortical origin, a surgeon who should operate at the middle part of the fissure of Rolando, as M. Lucas Championnière recommends, would incur the risk of missing the exact point of the lesion, which might be considerably above or below that point. He however recognises the probability of success by following these instructions when persistent aphasia coexists with paralysis of a single arm; and in all cases the issue of M. Bourdon's investigations goes to show that Championnière's advice to trepan at the top of the line of Rolando in paralysis of the inferior extremity, is well founded. But the advice to trepan behind the line of Rolando

is criticised by Bourdon, since in three instances he has known the lesion to be in front of it. As showing the importance of being able to localise the parts of the brain affected in certain conditions, Bourdon details a case in which Broca diagnosed and opened with the trephine an abscess seated at the level of the third left frontal convolution.

A. Rabagliati.

On the Influence of the Cerebrum in the Production of Epilepsy.—In recent numbers of the *Archiv. Italiano*, Professor Albertoni publishes an interesting report of work done in the physiological laboratory of the University of Siena; he has himself been studying the causation of epilepsy, and describes sixteen experiments made upon dogs, cats, and rabbits in the course of his investigations.

1. *The Epileptic Fit.*—After removing a portion of the skull of a dog, and dividing the dura mater so as to lay bare the posterior central convolution (in which almost all the centres from which muscular action may be excited are situated), a very weak induction current is passed for a short time through the centre for both extremities. The current used is so weak that it may be passed through the tongue without causing pain. The animal is at once attacked by general convulsions, and lies unconscious, the subject of clonic and tonic spasms; the pupils are widely dilated and do not react to the stimulus of light; saliva flows freely from the mouth. The convulsions cease gradually, after about two minutes, the dog rises and wanders about purposeless, running against various objects, then lies down, taking no notice of anything near him. The experiment may be repeated two or three times upon the same animal with the same result, but the current must be a little stronger each time. Upon one dog the writer performed the experiment successfully seven times in one day. The results were the same, whether the right or the left hemisphere were exposed and acted upon, also when the dura mater was not divided but the rheophores applied outside it. In the same cases the animal uttered a cry at the commencement of the fit; sometimes urination took place. The author also succeeded in causing a fit by pressing the trephined portion of the skull in upon the cortex in the same situation.

2. The experiment does not always succeed upon dogs: this the writer is unable to account for; it never, according to Albertoni, succeeds in rabbits to the extent of causing a true epileptic fit,

notwithstanding Ferrier's statement to the contrary. In cats the epileptic attack can be produced as in dogs.

3. The epileptic zone, that is to say, that part of the cortical substance in which the slightest electric stimulus gives rise to convulsion, is entirely limited to the posterior central convolution. In other convolutions the fit can only be caused by the application of strong currents, which are probably transmitted to the posterior central.

4. Anæsthesia prevents the development of the epileptic fit. In proof of this, two experiments are given. A dog was put under the influence of ether, and the electrodes then applied to the epileptic zone; the usual movements of the opposite extremities and neck resulted, but there was no epileptic fit. As soon as the effect of the ether had passed off, the electrodes were again applied, and a fit was at once produced. In the second case, a dog which immediately had a strong fit every time that the sensitive zone was stimulated by electricity, had a strong solution of chloral injected into the femoral vein; after this, strong currents were applied in the usual situation; the dog lifted his right extremities, but had no convulsion.

5. Five experiments were made upon dogs with the view of ascertaining whether the brain-cortex acts autonomously, or by means of a reflex in the causation of a fit. The epileptic zone was removed from each cerebral hemisphere; the electrodes being then applied, convulsions ensued, at first of the opposite side only, but they afterwards became general; after a short time no further reaction could be obtained. From this the author concludes that the cortical layers of the cerebrum do not themselves directly cause the epileptic fit, but that they do so by means of a reflex through the motor centres at the base of the brain.

6. The increase in the secretion of saliva during the epileptic seizure is due to stimulation of the sub-maxillary gland through the chorda tympani. Two experiments are adduced in proof of this.

On Atrophy of the Spinal Cord after division of the Spinal Nerves.—A series of experiments carried out by Drs. Bufalini and Rossi confirm Vulpian's statement that the changes in the spinal cord after partial or complete amputation of a limb, consist only in diminution of the size of the tissue elements, and not in any qualitative change in them. This observation is opposed to Hayem's view that, as a result of physiological inactivity after amputation or simple division of the nerves, myelitis with destruction of the nerve-cells of the grey matter takes place.

On increase in the Cardiac Pulsations after irritation of the roots of the Upper Dorsal Nerves.—Albertoni and Bufalini find as a result of their experiments, that irritation of the roots of the first six dorsal nerves markedly accelerates the action of the heart, and that this takes place through the instrumentality of the sympathetic system. The same effect is produced when the blood-pressure is lessened by division of the spinal cord, or by the action of chloral.

Notes on the Objects of Sphygmography in Psychological Medicine.—This paper, which was read before the "Psychiatrischer Verein der Rheinprovinz," is reported in the *Allgemeine Zeitschrift für Psychiatrie*, Band 35, Heft 1.

Although sphygmographic observations are somewhat tedious and troublesome, the neglect of them is the less excusable now that they are every day playing a more important part in general medicine. Wolff's observations led him to the following conclusions:—(1) the normal pulse in incurable insanity is the "pulsus tardus;" (2) this pulse is to be regarded as an indication of the neuropathic constitution upon which the psychosis is developed; (3) patients who have apparently recovered, but still retain this peculiar pulse, have in reality not recovered at all. The author fully confirms the observation that in the insane, especially the incurable, a pulse-curve is generally found which belongs to the class described by Wolff. This circumstance, however, does not suffice to establish Wolff's other conclusions. When it is remembered that the latter observer included under the term "pulsus tardus" many more varieties of pulse-curve than Landois; also that his supposition that a paralysis of the vaso-motor nervous system was the cause of this variety of pulse, is not reconcilable with Landois' theory; it will be seen that other questions have to be answered before the results of sphygmography in the study of mental disease can be so explicitly formulated.

It is first necessary to determine whether the pulse in question may not sometimes be observed in perfectly sane persons. The author has made some observations with this object, but they are not numerous enough to justify any definite conclusion; he noticed, however, that in certain cases, young men who were strong, had good mental abilities, and were in no way diseased, exhibited abnormal pulse-forms, *e.g.*, dicrotism; also that, especially among women, it is not at all uncommon to find the "pulsus tardus" in various degrees. This led the author to suspect that perhaps the

abnormality of the pulse in these persons might be due to feeble development of the muscular coat of the arteries, and therefore to a cause which has nothing to do with disturbed innervation or a neuropathic constitution.

Another subject of investigation should be the question as to how far the heart's action influences the production of the various pulse-phases. Wolff showed long ago that valvular disease produced corresponding changes in the pulse-curves, but it is desirable to know whether some more delicate changes in the heart cannot be shown to exist in some cases with "pulsus tardus." If the two conditions were found to co-exist, it could go far to deprive the pulse under consideration of its supposed nervous character. Combined observations with the sphygmograph and cardiograph would be not only possible, but would probably yield interesting results.

Suppose, however, that in a given case the existence of any abnormality either in the arterial muscular coats or in the heart could be with certainty excluded, and, in the absence of local causes, the appearance of a "tardy" pulse-curve might justifiably be ascribed to change in the innervation of the vessels; the question would still remain whether the vaso-motor disturbance was general or only partial, perhaps unilateral. To decide this, other arteries beside the right radial must be examined. Eulenburg and Mendel have made observations in this direction; the latter has published some very instructive comparisons between the radial and carotid tracings. The vaso-motor centre has always been assumed to be a double organ, and Eulenburg found in his experiments on the influence of injuries of the cerebral cortex upon vascular innervation that the effects produced were unilateral and upon the side opposite to the injury. It is easy to understand how high temperatures, poisons, or psychic impressions should cause the disturbance of vascular innervation to be general, but it would be difficult to explain how, in the course of a psychosis, the characters of the pulse-curve should be similarly affected in all regions of the body. A morbid change, of exactly the same nature, proceeding at exactly the same rate in each of the two halves of the central nervous system, would have to be assumed if it were held that this general and similar alteration in the pulse-tracings throughout the body were due to disturbance of the innervation of the vessels.

CHAS. S. W. COBBOLD, M.D.